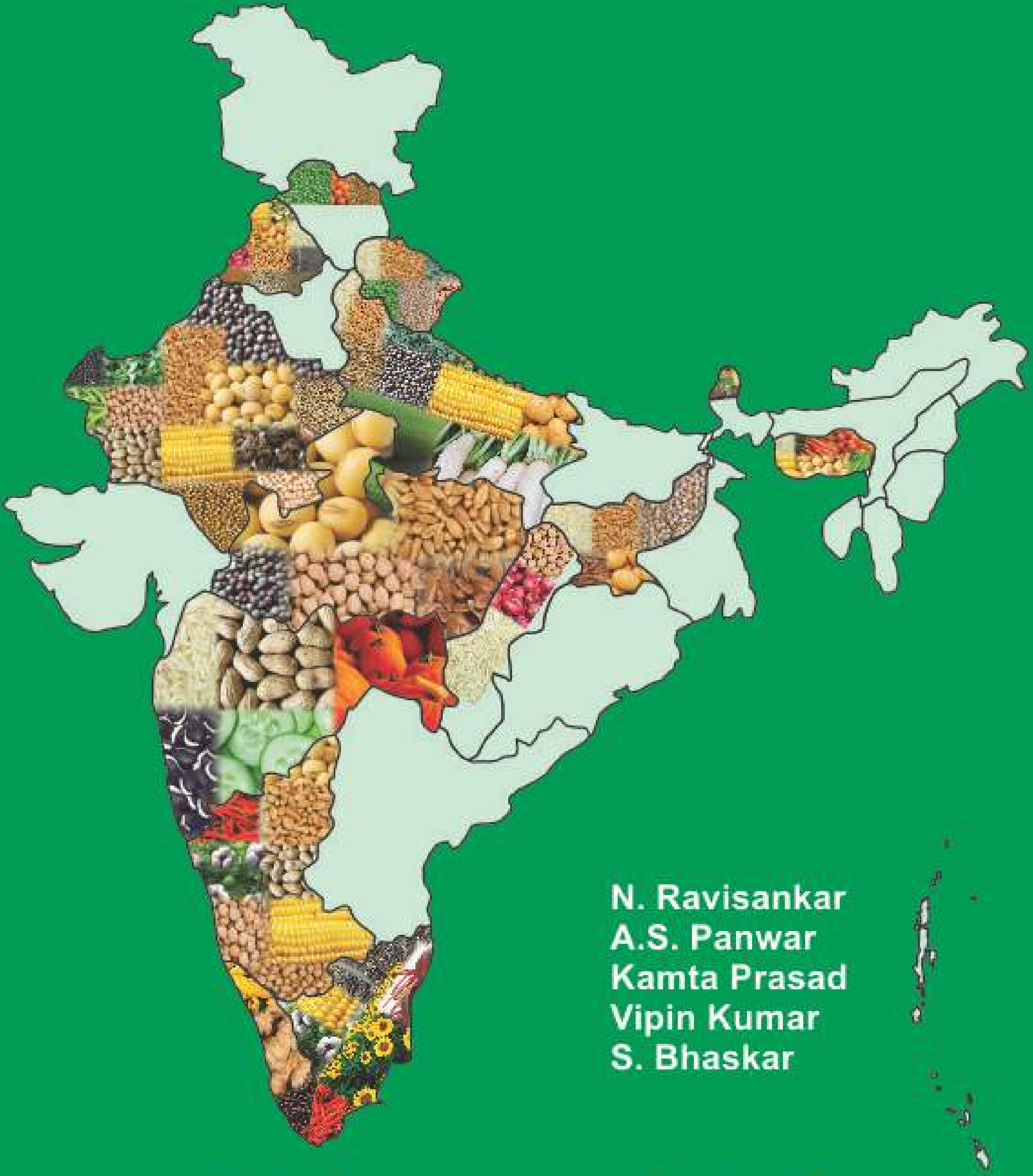
Organic Farming
(Crop Production Guide)



N. Ravisankar
A.S. Panwar
Kamta Prasad
Vipin Kumar
S. Bhaskar

Network Project on Organic Farming
ICAR-Indian Institute of Farming Systems Research
Modipuram, Meerut - 250 110 (U.P.)

Organic Farming
(Crop Production Guide)

Editors
N. Ravisankar
A.S. Panwar
Kamta Prasad
Vipin Kumar
S. Bhaskar

Network Project on Organic Farming
ICAR-Indian Institute of Farming Systems Research
Modipuram, Meerut- 250 110 (Uttar Pradesh)

www.iifsr.res.in

Citation: Ravisankar, N., A.S. Panwar, Kamta Prasad, Vipin Kumar and S. Bhaskar. 2017. Organic Farming Crop Production Guide, Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh, India. p. 586.

ISBN No.
978-81-928993-3-6

Edited and compiled by
N. Ravisankar, A.S. Panwar, Kamta Prasad, Vipin Kumar and S. Bhaskar

Concept, layout and graphics
N. Ravisankar, Principal Scientist and National PI, NPOF
Kamta Prasad, Former Principal Scientist

Technical Assistance
Vipin Kumar, CTO (NPOF)

Cover design and maps
Shri Manoj Kumar, RA, CU

Published by
Director
ICAR-Indian Institute of Farming Systems Research
Modipuram, Meerut-250 110, Uttar Pradesh, India

Printed at
M/s Yugantar Prakashan Pvt. Ltd., WH-23 Mayapuri Industrial Area, Phase-I, New Delhi-64
Phones: 011-28115949, 28116018; Mobile: 09811349619, 09953134595

f=ykpu egkik=] ih,p-Mh-
एफ.एन.ए, एफ.एन.ए.एससी., एफ.एन.ए.ए.एस.
सचिव एवं महानिदेशक
Trilochan Mohapatra, Ph.D.
FNA, FNASc, FNAAS
Secretary & Director General

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन,
नई दिल्ली 110 001
Government of India
Department of Agricultural Research & Education
and
Indian Council of Agricultural Research
Minsitry of Agriculture and Farmers Welfare
Krishi Bhawan, New Delhi-110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

Organic agriculture is practiced in 170 countries with total area of 78 million ha (both in the form of cultivated and wild harvest). Emerging from 42,000 ha under certified organic farming in 2003-04, the organic agriculture has grown many folds and by 2014-15, India has brought 4.89 m ha area under organic certification process. Out of this, cultivated area accounts for 1.18 m ha (24.1 %) while remaining 3.71 m ha (75.9 %) is wild forest harvest collection area. Currently, India ranks 10th among the top ten countries having the cultivable land under organic certification. Around 6.50 lakhs organic producers are engaged in the country in various forms.

India being a country with different agro-climatic zones, each state produces its own specialty products with differential management practices. Integrated approach of crop management – including integrated nutrient management and inter/mixed cropping – is also considered as ***“towards organic”*** approach; and at the same time has been found to increase the use efficiency of all costly inputs especially fertilizers and water, it would be appropriate to adopt it in the food bowl areas contributing major share to the food basket. This approach will also contribute to *‘more crop per drop and less land, less resource/ time and more production’* strategies of the government.

Different parts of India have developed their own local or regional systems for ecological agriculture that are now gathered in one umbrella term ‘*Jaivik Krishi’* or *‘Jaivik Kheti’*. India has a sizable cropped area in different states, which is more prone to weather vagaries; especially those located in rainfed, dryland and hilly areas. Increasing the agricultural productivity and income of the farmers as well as sustaining soil resource in these agricultural systems has always been a challenging task for researchers and policy planners. Use of fertilizers and pesticides is minimal and much below the national average in these areas. At first instance, these are the areas which need to be targeted for organic production by devising proper strategies and identifying niche crops (crops which yield higher under organic production systems and have adequate market demand).

Government of India has promoted organic agriculture through various developmental programmes and schemes which includes National Programme for Organic Production (NPOP), National Project on Organic Farming (NPOF), National Mission on Sustainable Agriculture (NMSA) and Paramparaghat KrishiVikasYojana (PKVY). Considering the importance of Organic Farming, Indian Council of Agricultural Research (ICAR) launched Network Project on Organic Farming during 2004 with 13 centres covering 12 states to study the changes in crop productivity and soil health and also to develop scientific package of practices for organic production of crops in cropping/farming systems perspective.The results of the study clearly indicates that adoption of scientific organic farming practices are essential to keep the crop productivity at comparable or higher level and these practices needs to be adopted in the developmental schemes. I congratulate the editors for bringing out the publication on ***“Organic Farming Crop Production Guide”*** having scientific package of practices for organic production of crops in cropping/farming systems perspective. I hope that the book will be highly useful for all the stake holders involved in organic farming.

(T. Mohapatra)

PREFACE

Backed by continued science led technological innovations in the agriculture sector, India's food grain production has more than doubled over the decades to a record 264 mt in 2014. The country has 11.3 % of world arable landwith one-fourth of the world population depending on agriculture living in India. Inspite of technological advancements, the lower productivity prevails in paddy, maize, pulses and soybean to the extent of 18 to 53 % compared to world average productivity which is mainly attributed to large dependency on rainfall and other climatic conditions for good yield. The irrigated area produces about 56% of total food requirement of India. The remaining 44% of the total food production is supported by rainfed agriculture. Most of the essential commodities such as coarse cereals (90%), pulses (87%), and oil seeds (74%) are produced from the rainfed agriculture. These statistics emphasise that rainfed regions play a major role in ensuring food for the ever-growing population. The rainfed regions are predominantly marked by low cropping intensity, relatively low organic matter status, poor soil physical health and low fertility. Further, moisture stress accompanied by other soil related constraints also results in low productivity of crops. As per FAO definition, food security is not only the ability to produce but also to access food. According to the data put out by international agencies, 70 % of world's food is produced by small holders and 30 % by the agri-business sector. A report by United Nations Conference on Trade and Development (UNCTAD) and United Nations Environment Programme (UNEP), found that organic agriculture is more conducive to food security and is more sustainable in the long term. There are two significant areas where organic systems have higher yields than conventional systems. These are under conditions of climate extremes and in small holder systems. Both these areas are critical to achieving safe food security for future in India. Organic farmers grow a variety of crops and livestock in order to optimize competition for nutrients. This results in less chance of low production, improved availability and positively impact local food security. Studies by national and international agencies have proved the three different aspectsin organic agriculture systems. They are 1. organic systems may decrease yields depending on intensity of inorganic inputs used before conversion; 2. In irrigated lands, conversion to organic agriculture may lead to almost identical yields over a period of time and 3. In low- input, traditional/rainfed agriculture, conversion to organic agriculture has potential to increase yields.Hence, having 53.6 % area under rainfed and rainfall extremes in various parts of the country, promotion of organic agriculture in niche areas and crops is essential for having safe food security in future.

Organic farming systems are very much native to Indian Agriculture. Traditionally, precisely before dawn of the green revolution, crops and livestock have been reared together in all the farm households. And, as of now also, in more than 85% of the farm-households field crops + livestock farming system is prevailing. The total factor productivity (TFP) growth score prepared by National Institute of Agricultural Economics and Policy Research has revealed that technology-driven growth has been highest in Punjab and lowest in Himachal Pradesh. It implies that some of the states like Himachal Pradesh, Uttarakhand, Madhya Pradesh, Rajasthan, Jharkhand and north-eastern region of India have not been influenced much by the modern inputs of agriculture like chemical fertilizers and pesticides. Moreover, despite all technological advancements, the nutrient use efficiency is on lower side (33% for N, 15% for P and 20% for K and micronutrients). On the other hand it has been proved scientifically and convincingly that integrated use of organic manures with chemical fertilizers improves the use efficiencies of the latter owing to concurrent improvement of soil physical, chemical and biological properties. The water holding capacity of the soil also gets improved on account of regular use of organic manures. It is estimated that various organic resources having the total nutrient potential of 32.41 million tonnes will be available for use in 2025. Out of these organic resources, considerable tapable potential of nutrients ($N + P_2O_5 + K_2O$) from human excreta, livestock dung and crop residues have been worked out to be only 7.75 million tonnes.

As we know, organic is more of a description of the agricultural methods used on a farm, rather than food itself and those methods combine tradition, innovation and science. The food production is confronted with many problems of declining soil health, water level, environment concern, new pest/ disease problems and health concerns due to excessive use of resources. The climatic concerns are further aggravating the problems to farming systems. Indian agriculture is considered to be the backbone of livelihood of more than 70% of the population. In facts, small and marginal holders which constitute about 86% of the households are considered to be the key for transformation of the status of developing country to developed country in the world. However, small and fragmented marginal farm holders may not afford the high input intensive cultivation. This group of farmers requires the packages of low cost with high profit margins. The integration of more than two enterprises and organic farming practices requires due attention to address the present problems in agriculture and small farm holders in particular. The increasing research and development efforts in recent years on integrated farming systems including organic farming at the country level by government of India, States initiatives and Indian council of Agricultural Research have pared the way toward organic farming systems.

For promoting organic farming at the country level some research efforts were made and technologies developed specially under NPOF having 13 centres. Some philosophical publications for promoting organic farming are also available. But, the technologies based on the research efforts and strategies for different agro-climatic zones and states are not readily available. Therefore, based on research efforts, package of practices have been developed for many cropping systems suitable for different states. These were compiled in the form of organic crop production guide. Besides PoPs, general information on niche crops, areas, certification and NPOP standards have also been added for ready reference.

Editors

CONTENTS

LIST OF CONTRIBUTORS

Chaper 1 Organic Farming in India: Production Issues and Strategies

N. Ravisankar, Principal Scientist, National Principal Investigator, Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
SK Sharma, Professor (Agronomy) & PI, NPOF, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan
D.K. Singh, Professor & PI, NPOF, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand
A.S. Panwar, Director, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
Vipin Kumar, Chief Technical Officer, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

Chaper 2 Nutrient Management in Organic Farming: Principles and Practices

D.K. Singh, Professor & PI, NPOF, Department of Agronomy, College of Agriculture, GBPUA&T, Pantnagar-263145, District-Udham Singh Nagar (Uttarakhand)
Shilpi Gupta, Senior Research Fellow, Department of Agronomy, College of Agriculture, GBPUA&T, Pantnagar-263145, District-Udham Singh Nagar (Uttarakhand)
Yogesh Sharma, Senior Research Fellow, Department of Agronomy, College of Agriculture, GBPUA&T, Pantnagar-263145, District-Udham Singh Nagar (Uttarakhand)

Chaper 3 Weed Management in Organic Farming

Jayanta Layek, Scientist, ICAR Research Complex for NEH Region Umroi Road, Umiam-793 103, (Meghalaya)
Ramkrushna GI, Scientist, ICAR Research Complex for NEH Region Umroi Road, Umiam-793 103, (Meghalaya)
Subhash Babu, Scientist, ICAR Research Complex for NEH Region Umroi Road, Umiam-793 103, (Meghalaya)
Anup Das, Principal Scientist, ICAR Research Complex for NEH Region Umroi Road, Umiam-793 103, (Meghalaya)

Chaper 4 Pest, Disease Identification and Management in Organic Crop Production

Chandra Bhanu, Scientist, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
N. Ravisankar, Principal Scientist, National Principal Investigator, Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
A.S. Panwar, Director, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

Chaper 5 Organic Package of Practices

Chhatisgarh

Indira Gandhi Krishi Vishwa Vidyalaya, Raipur

M.C. Bhambri, Professor
S.K. Agrawal, Scientist
Anup Singh, Scientist
Ashok Pal, Senior Research Fellow
P.C. Kanwar, Senior Research Fellow
P.L. Sahu, Senior Research Fellow
S. Navrang, Senior Research Fellow

Himachal Pradesh

CSK HPKV, Hill Agricultural Research and Extension Centre Bajaura, Kullu

D.K. Parmar, Principal Scientist
D.R. Thakur, Principal Scientist
J.K. Sharma, Principal Scientist
R.S. Jamwal, Principal Scientist
R.K. Devlash, Senior Scientist
Arpana, Senior Research Fellow
Neha, Senior Research Fellow
Brij Bala, Principal Scientist
S.D. Sharma, Principal Scientist

Jharkhand

Birsa Agricultural University, Ranchi

C.S. Singh, Jr. Scientist cum Assistant Professor
S.K. Singh, Senior Research Fellow
R.K. Verma, Senior Research Fellow

Karnataka

University of Agricultural Sciences, Dharwad

H.B. Babalad, Professor
L.H. Malligawad, Professor
S.A. Gaddanakeri, Principal Scientist

Kerala

ICAR-Indian Institute of Spices Research, Kozhikode

C.K. Thankamani, Principal Scientist
V. Srinivasan, Principal Scientist
S. Hamza, Chief technical Officer
T. John Zachariah, Principal Scientist
R. Dinesh, Principal Scientist

ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram

G. Suja, Principal Scientist
A.N. Jyothi, Principal Scientist
J. Sreekumar, Principal Scientist

Madhya Pradesh

ICAR-Indian Institute of Soil Science, Bhopal

A.B. Singh, Principal Scientist
K. Ramesh, Principal Scientist
S. Ramana, Principal Scientist
J.K. Thakur, Scientist
B.L. Lakaria, Principal Scientist

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

S.K. Vishwakarma, Assistant Professor
R.P. Sahu, Assistant Professor
V.K. Shukla, Professor

Maharashtra

Agricultural Research Station, Dr. BS Konkan Krishi Vidyapeeth, Karjat

L.S. Chavan, Professor
D.G. Jondhle, Assistant Professor
S.J. Mhatre, Senior Research Fellow
S.S. More, Senior Research Fellow
S.K. Kshirsagar, Senior Research Fellow

Meghalaya

ICAR Research Complex for North Eastern Region, Umiam

Anup Das, Principal Scientist
Ramkrushna G.I., Scientist
Jayanta Layek, Scientist
Subash Babu, Scientist
Bidyapati Ngangom, Research Fellow
Dauni Suting, Research Fellow

Punjab

Punjab Agricultural University, Ludhiana

C.S. Aulakh, Senior Agronomist
Amandeep Kaur, Senior Research Fellow

Rajasthan

Maharana Pratap University of Agriculture and Technology, Udaipur

S.K. Sharma, Professor
Amit Trivedi, Associate Professor
R.K. Sharma, Assistant Professor
L.K. Chatta, Associate Professor
P. Jambhulkar, Assistant Professor

Ramesh Babu, Assistant Professor
Hargilas, Assistant Professor

Sikkim

ICAR-National Organic Farming Research Institute, Tadong, Gangtok

R.K. Avasthe, Joint Director
Raghavendra Singh, Senior Scientist
Subash Babu, Scientist
Ashish Yadav, Senior Scientist
H. Kalita, Principal Scientist
R. Gopi, Scientist Senior Scale
Shaon Kumar Das, Scientist

Tamil Nadu

Tamil Nadu Agricultural University, Coimbatore

E. Somasundaram, Professor and Head
S. Ramasamy, Former Professor and Head
R. Parimala Devi, Associate Professor

Uttar Pradesh

ICAR-Indian Institute of Farming Systems Research, Modipuram

N.K. Jat, Scientist
R.S. Yadav, Principal Scientist
Sudhir Kumar, Scientist
Chandra Bhanu, Scientist
Prem Singh, Principal Scientist
N. Ravisankar, Principal Scientist

Uttarakhand

GB Pant University of Agriculture and Technology, Pantnagar

D.K. Singh, Professor
K.P. Raverkar, Professor
Chandra Bhushan, Professor
Shilpi Gupta, Senior Research Fellow

Chapter 6 **Niche Areas and Crops for Promotion of Organic Farming**

N. Ravisankar, Principal Scientist, National Principal Investigator, Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
A.S. Panwar, Director, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

Chapter 7 **Minutes of Workshop on Organic Farming: Concerns About Crop Productivity and Soil Health**

N. Ravisankar, Principal Scientist, National Principal Investigator, Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
Vipin Kumar, Chief Technical Officer, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

Chapter 8 **Technologies Recommended for Up-Scaling in XI Annual Group Meeting of NPOF**

N. Ravisankar, Principal Scientist, National Principal Investigator, Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
A.S. Panwar, Director, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

Chapter 9 **Certification, Labelling and Accreditation Procedures**

A.S. Panwar, Director, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
Vipin Kumar, Chief Technical Officer, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

Chapter 10 **List of Accredited Certification Bodies under NPOP**

Vipin Kumar, Chief Technical Officer, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

Chapter 11 **Important Publications and Websites on Organic Farming in Indian Context**

N. Ravisankar, Principal Scientist, National Principal Investigator, Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh
A.S. Panwar, Director, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

CHAPTER 1

Organic Farming in India: Production Issues and Strategies

Organic farming systems are very much native to Indian Agriculture. As of now also, in more than 85% of the farm-households, crop + livestock farming system is prevailing. Nevertheless, during pre-green revolution period (up to 1960s) the rate of national agricultural growth was not able to keep pace with population growth and virtually 'ship to mouth' situation prevailed. This was the major factor for introduction and large-scale popularization of the high yielding varieties (HYVs) of crops, which were highly responsive to the chemical fertilizers and water use. As a result, the total food grain production increased phenomenally – from mere 50.82 million tonnes in 1950-51 to 264.00 million tonnes in 2013-14 – indicating a 5-times increase. This increase can be primarily attributed to large-scale adoption of HYVs, combined with other green revolution technologies (GRTs) in cereal crops, expansion of gross irrigated area (22.56 million ha in 1950-51 to 89.36 million ha in 2010-11) and increase in fertilizer consumption (0.07 million tonnes in 1950-51 to 25.54 million tonnes in 2012-13). All of them put together have led to substantial increase in the productivity of crops, especially food grains (from 522 kg/ha in 1950-51 to 2125 kg/ha in 2012-13) culminating into the change in the status of India from a food importer to net food exporter in many commodities.

However, total factor productivity growth score prepared by National Institute of Agricultural Economics and Policy Research has revealed that technology-driven growth has been highest in Punjab and lowest in Himachal Pradesh. It implies that some of the states like Himachal Pradesh, Uttarakhand, Madhya Pradesh, Rajasthan, Jharkhand and north-eastern region of India have not been influenced much by the modern inputs of agriculture like chemical fertilizers and pesticides. India's average fertilizer and pesticide consumption stands at 128.3 kg/ha and 0.31 kg a.i./ha, respectively. Moreover, despite all technological advancements, the nutrient use efficiency is on lower side (33% for N, 15% for P and 20% for K and micronutrients). On the other hand, it has been proved scientifically and convincingly that integrated use of organic manures with chemical fertilizers improves the use efficiencies of the latter owing to concurrent improvement of soil physical, chemical and biological properties. The water holding capacity of the soil also gets improved on account of regular use of organic manures. It is estimated that various organic resources having the total nutrient potential of 32.41 million tonnes will be available for use in 2025. Out of these organic resources, considerable tapable potential of nutrients (N + P_2O_5 + K_2O) from human excreta, livestock dung and crop residues have been worked out to be only 7.75 million tonnes.

Area under organic farming, production and export

In world, 78 million ha area in 170 countries is under organic agriculture which includes both cultivated and wild harvest. Emerging from 42,000 ha under certified organic farming in 2003-04, the organic agriculture has grown many folds and by 2014-15, India has brought 4.89 m ha area under organic certification process. Out of this cultivated area accounts for 1.18 m ha (24.1 %) while remaining 3.71 m ha (75.9 %) is wild forest harvest collection area. Currently, India ranks 10th among the top ten countries having the cultivable land under organic certification. In terms of wild collection, India ranks 3rd next to Finland and Zambia. Around 6.50 lakhs producers are engaged in the country in various forms. Sikkim state has been declared as organic state from January 2016 and has highest net sown area (100 %) under organic certification while Madhya Pradesh is having largest area (2,32,887 ha) under organic production system. The domestic market for organic products in the year 2014-15 was estimated at Rs. 875 crores. India being a country with different agro-climatic zones, each state produces its own specialty products. Export volume and value from the country during last 3 years indicates highest volume of export to USA and in terms of Value to European Union during 2013-14 and over the years it has grown drastically. Among the various commodities exported, soybean shares 70 %. India's first internationally certified organic products emerged in the mid 70's, supported by UK's Soil Association. Different parts of India have developed their own local or regional systems for ecological agriculture that are now gathered in one umbrella term '*Jaivic Krishi' or 'Jaivik Kheti'*.

Concept and Principles organic farming

Historically, the concept of organic farming in India and China is based on following principles:

- Nature is the best role model for farming, since it does not use any inputs nor demand unreasonable quantities of water.
- The entire system is based on intimate understanding of nature's ways. The system does not believe in mining of the soil of its nutrients and do not degrade it in any way.
- The soil in this system is a living entity and the soil's living population of microbes and other organisms are significant contributors to its fertility on a sustained basis and must be protected and nurtured at all cost.
- The total environment of the soil, from soil structure to soil cover is more important.

In its simplistic form, organic agriculture may be defined as "a kind of diversified agriculture wherein crops and livestock are managed through use of integrated technologies with preference to depend on resources available either at farm or locally". Other benefits of organic agriculture are its reliance on fossil fuel independent, locally available resources that incur minimal agro-ecological stresses and are cost-effective.

The organic community has adopted four basic principles, and broadly speaking, any system using the methods of organic agriculture and being based on these principles, may be classified as organic agriculture:

- **The principle of health:** Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.
- **The principle of ecology:** Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.
- **The principle of fairness:** Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.
- **The principle of care:** Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and wellbeing of current and future generations and the environment.

Components of organic farming

Essential components of organic farming are keeping the soil alive through effective management of natural resources. They are as follows

- **Enrichment of soil:** Abandon use of chemicals, use crop residue as mulch, use organic and biological fertilizers, adopt crop rotation and multiple cropping, avoid excessive tilling and keep soil covered with green cover or biological mulch.
- **Management of temperature:** Keep soil covered, plant trees and bushes on bund
- **Conservation of soil and rain water:** Dig percolation tanks, maintain contour bunds in sloppy land & adopt contour row cultivation, dig farm ponds, maintain low height plantation on bunds.
- **Harvesting of sun energy:** Maintain green stand throughout the year through combination of different crops and plantation schedules.
- **Self-reliance in inputs:** Develop your own seed, on-farm production of compost, vermicompost, vermiwash, liquid manures and botanical extracts.
- **Maintenance of life forms:** Develop habitat for sustenance of life forms, never use pesticides and create enough diversity.
- **Integration of animals:** Animals are important components of organic management and not only provide animal products but also provide enough dung and urine for use in soil.
- **Use of renewable energy:** Use solar energy, bio-gas and other eco-friendly machines.

Different forms of organic agriculture

Rishi Krishi: Drawn from Vedas, the Rishi Krishi method of natural farming has been mastered by farmers of Maharashtra and Madhya Pradesh. In this method, all on-farm sources of nutrients including composts, cattle dung manure, green leaf manure and crop biomass for mulching are exploited to their best potential with continuous soil enrichment through the use of Rishi Krishi formulations known as “*Amritpani*” and virgin soil.

Panchgavya Krishi: Panchgavya is a special bio-enhancer prepared from five products obtained from cow; dung, uine, milk, curd and sometimes ghee. Panchgavya contains many useful microorganisms such as fungi, bacteria, actinomycetes and various micronutrients. The formulation act as tonic to enrich the soil, induce plant vigour with quality production.

Natural farming: Natural farming emphasizes on efficient use of on-farm biological resources and enrichment of soil with the use of Jivamruta to ensure high soil biological activity. Use of Bijamruta for seed/ planting material treatment and Jivamruta for soil treatment and foliar spray are important components.

Natueco Farming: Natueco Farming emphasizes 'Neighborhood Resource Enrichment' by 'Additive Regeneration' rather than through dependence on external, commercial inputs. The three relevant aspects of Natueco Farming are:

- Soil **-** Enrichment of soil by recycling of the biomass by establishing a proper energy chain.
- Roots **-** Development and maintenance of white feeder root zones for efficient absorption of nutrients.
- Canopy **-** Harvesting the sun through proper canopy management for efficient photosynthesis.

Homa Farming: Homa farming has its origin from vedas and is based on the principle that "you heal the atmosphere and the healed atmosphere will heal you" The practitioners and propagators of homa farming call it a "revealed science". It is an entirely spiritual practice that dates from the Vedic period. The basic aspect of homa farming is the chanting of Sanskrit mantras (Agnihotra puja) at specific times in the day before a holy fire.

Biodynamic Agriculture: Method of farming that aims to treat the farm as a living system which interacts the environment, to build healthy, living soil and to produce food that nourishes and vitalizes and helps to develop mankind. The underlying principle of biodynamics is making life-giving compost out of dead material. The methods are derived from the teachings of Rudolf Stainer and subsequent practitioners. The important components of biodynamic farming are turning in plant materials such as green crops and straw, not using chemical fertilizers and pesticides, avoiding soil compaction by machinery or animals, particularly in wet weather, keeping soil covered by pasture, crops or mulch not destroying the soil structure by poor farming practices such as excessive use of rotary hoe or cultivation in unsuitable weather (too wet or too dry), fallowing the land by planting deep-rooting permanent pasture species or using green crops, use of preparations BD-500 and BD-501, compost made with preparations BD-502 – BD-507, liquid manure made with preparations BD-502 – BD-507 and cowpat pit manure made with preparations BD-502 – BD-507. Till now, 9 biodynamic preparations have been developed, named as formulation 500 to 508. Out of these, formulation-500 (cow horn compost) and formulation- 501 (horn-silica) are very popular and are being used by large number of organic farmers. Formulations-502 to 507 are compost enrichers and promoters, while formulation 508 is of prophylactic in nature and helps in control of fungal diseases.

Organic and towards organic agriculture

Organic is more of a description of the agricultural methods used on a farm, rather than food itself and those methods combine tradition, innovation and science. Organic agriculture, in simple terms, requires a shift from intensive use of synthetic chemical fertilizers, insecticides, fungicides, herbicides, PGRs, genetically engineered plants to extensive use of animal manures, beneficial soil microbes, bio-pesticides, bio-agents and indigenous technological knowledge, based on scientific principles of agricultural systems. Scientific evidences clearly establish that conversion of high intensive agriculture areas to organic systems lead to reduction in crop yields considerably (up to 25-30%), especially during initial 3-4 years; before soil system regains and crop yields come to comparable level. In this scenario, if all the cultivated areas are brought into organic production systems, the national food production system may get jeopardized; hence a phased approach may be desirable. Considering this fact on one hand and looking into global scenario of organic agriculture, working group on Horticulture, Plantation Crops and Organic Farming for the XI-Five-Year Plan suggested a spread of organic farming on 1-5 per cent area in

Towards organic approach (integrated crop management) in wheat
(Source: NPOF centre, Bhopal)

the high productive zones and larger spread in the less exploited areas, such as, rainfed and hill areas. Nevertheless, integrated approach of crop management – including integrated nutrient management and inter/ mixed cropping – is also considered as **"towards organic"** approach; and at the same time has been found to increase the use efficiency of all costly inputs especially fertilizers and water, it would be appropriate to adopt it in the food bowl areas contributing major share to the food basket. This approach will also contribute to **'more crop per drop and less land, less resource/ time and more production'** strategies of the government.

Further, India has a sizable cropped area in different states, which is more prone to weather vagaries; especially those located in rainfed, dryland and hilly areas. Increasing the agricultural productivity and income of the farmers as well as sustaining soil resource in these agricultural systems has always been a challenging task for researchers and policy planners. Presently, in these areas use of fertilizers and pesticides is minimal and much below the national average. At first instance, these are the areas which need to be targeted for organic production by devising proper strategies and identifying niche crops (crops which yield higher under organic production systems and have adequate market demand). The domestic and export markets must be exploited for increasing the income of the farmers, as it is important to note that 78% of Indian organic consumers prefer Indian brand of organic and many other countries also require diversified organic foods of tropical fruits, vegetables, essential oils, flowers, herbs, spices and organic cotton from India. In addition, large-scale adoption of organic agriculture in such areas will not only help in conserving the environmentally fragile ecosystems but also help in supplementing overall food production of the country. This can be clearly brought out by the example of Sikkim – an agriculturally weak state located in north-eastern hills region of the country. During 2002-03 (before Sikkim Organic Mission) fertilizer consumption was the highest (21.5 kg/ha), the productivity of rice was 1.43 t/ha but 11 years later, i.e., during 2013-14, it increased to 1.81 t/ha, and more interestingly, no yield reduction was observed during conversion period. Productivity increase in other crops was also noted to the tune of 11%, 17% and 24% in maize, finger millet and buckwheat, respectively.

Practical production issues and strategies for success

Although several issues exist for organic growers, practically there are three major issues which constraints the productivity of crops under organic farming compared to conventional farming. These issues are

A. **Supply of sufficient nutrient through organic management:** Crop needs nitrogen, phosphorus, potassium and several other secondary and micro nutrients for assimilation and better biomass output. These nutrients need to be supplied in a form which does not have synthetics and environmental degradation. Organic farming discussion starts with the question that how to meet the nutrient requirement of crops through organic manures and where it is available?

B. **Insect and disease management:** Another important issue which directly related to crop productivity and environment. Is it possible to manage the pests and diseases without using synthetics?

C. **Weed management:** It is the major issue for many of the organic growers as it has been observed that under organic management, weeds grow intensively if manures from outside the farm are used?

Strategies for success

A. Supply of sufficient nutrient through organic management

Enough scope for production of sufficient organic inputs exists in India and it works out to 7 mt in terms of nutrients. Among different sources, livestock accounts for major share (nearly 40 per cent). It is followed by crop residues (30 per cent) and other sources (15 %). Other sources include the rural compost, vermi-compost and agricultural wastes. Further, concept of promoting organic farming in individual crops should be done away and it should be practiced in cropping/farming systems. The issue of sufficient nutrient supply under organic systems can be addressed through following measures.


Integrated Organic Farming System (IOFS) model established at Umiam
(Source: NPOF centre, Umiam)

1. **Practice through farming system:** Organic farming is considered incomplete without livestock as livestock alone contributes nearly 40 % of total organic manures in the country. Crop + dairy are the pre-dominant farming system practiced traditionally by Indian

farmers over the centuries. Analysis of farming systems practiced by 732 marginal households across the 30 NARP zones indicated existence of 38 types of farming systems. Out of this, 47 % of households have the integration of crop + dairy, 11 % have crop + dairy + goat and 9 % households have crop + dairy + poultry systems. Hence, natural strength exists in the country for promotion of organic and towards organic agriculture. Integrated Organic Farming Systems (IOFS)**:** Integrated organic farming system models established at Coimbatore (Tamil Nadu) and Umiam (Meghalaya) under Network Project on Organic Farming (NPOF) could improve the net returns by 3 to 7 times compared to existing systems (Table 1) and meet up to 90 % of seeds/planting materials, nutrients, bio-pesticides and other inputs with in the farm in the two years of establishment.

Table 1. Performance of integrated organic farming system models

Components	Area (ha)	Total cost (Rs/year)	Net returns (Rs/year)				
			Crop	Livestock	Others	Total	Existing system
Coimbatore (Tamil Nadu)							
Crop (Okra, cotton, desmanthus) + dairy (1 milch animal, 1 heifer & 1 bull calf) + vermicompost + boundary plantation	0.40	1,10,109	64,500 (87 %)	8,216 (11 %)	1,600 (2 %)	74,316	27,200*
Umiam (Meghalaya)							
Crops (Cereals + pulses + vegetables +fruits + fodder) + Dairy (1 cow + 1 calf) + Fishery + Vermicompost	0.43	68,255	33,531 (57 %)	13,252 (22 %)	11,538 (21 %)	58,321	8,618**

* fingermillet – cotton - sorghum, ** rice-fallow

2. **Multiple cropping and crop rotation:** Mixed cropping is the outstanding feature of organic farming in which variety of crops are grown simultaneously or at different time on the same land. In every year, care should be taken to maintain legume cropping at least 40%. In selecting crop combinations, it is also to be kept in mind that plants also have their feelings, likes and dislike e.g. maize gets along well with beans and cucumber, tomatoes go well with onions and marigold. On the other hand beans and onions do not go well with each other. Entire farm should have at least 8-10 types of crops at all the

Direct seeded rice + soybean under organic management
(Source: NPOF centre, Pantnagar)

times. Each field/ plot should have at least 2-4 types of crops out of which one should be legume. In case if only one crop is taken in one plot then adjacent plots should have different crops. For maintenance of diversity and pest control, vegetable seedlings can be planted randomly @ 50-150/acre which can be used for home consumption and 100 plants/acre of marigold in all crop fields. Crop rotation is the succession of different crops cultivated on same land. Follow 3-4 years rotation plan. All high nutrient demanding crops should precede and follow legume dominated crop combination. Rotation of pest host and non pest host crops helps in controlling soil borne diseases and pest. It also helps in controlling weeds. It is better for improving productivity and fertility of soil. Crop rotations help in improving soil structure through different types of root system. Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also find place in planning rotations. Principles with examples for selecting the crops and varieties for organic farming are given below.

- Non–leguminous crops should be followed by leguminous crops and vice-versa, eg. green gram – wheat / maize. If preceding crops are legume or non-legume grown as intercrops or mixed crops, the succeeding crop may be legume or non-legume or both.
- Restorative crops should be followed by exhaustive or non-restorative crops.eg. sesame – cowpea / green gram / blackgram / groundnut
- Leaf shedding crop should be followed by non-leaf shedding or less exhaustive crops.eg. pulses / cotton – wheat / rice
- Green manuring crop should be followed by grain crops.eg. dhaincha - rice, green gram/ cowpea – wheat / maize.
- Highly fertilized crops should be followed by less-fertilized crop.eg. maize - black gram/gourds.

- Perennial or long duration crops should be followed by seasonal /restorative crops. eg. napier / sugarcane - groundnut /cowpea /green gram.
- Fodder crops should be followed by field or vegetable crops. eg. maize + cowpea-wheat/potato/cabbage/onion.
- Multicut crops should be succeeded by the seed crops. eg. green gram/maize.
- Ratoon crops should be followed by deep rooted restorative crops. eg. sugarcane/ jowar-pigeonpea/lucerne/cowpea.
- Deep rooted crops should be succeeded by shallow rooted crops. eg. cotton/ castor/ pigeonpea – potato / lentil /green gram etc.
- Deep tillage crops should be followed by zero or minimal tillage crops. eg. potato / radish / sweet potato/sugarcane - black gram/green gram/green manuring crops.

3. **Green manures:** Green manures are the principal supplementary means of adding organic matter to the soil. The green-manure crop supplies organic matter as well as additional nitrogen, particularly if it is a legume crop, due to its ability to fix nitrogen from the air with the help of its root nodule bacteria. The green-manure crops also exercise a protective action against erosion and leaching. Green manure to be incorporated in soil before flowering stage because they are grown for their green leafy material, which is high in nutrients and protects the soil. Green manures will not break down in to the soil so quickly, but gradually, add some nutrients to the soil for the next crop. Green manure crops can also be inter cropped and incorporated which will have dual advantage of managing

Intercropping of *dhaincha* in rice and incorporation through cono weeder

weeds and soil fertility. Popularly grown green manures are Sesbania aculeate (Dhaincha), *Sesbania rostrata*, sunhemp etc.

4. **Combination of organic nutrient sources:** Combining more than one organic source for supplying nutrients to crops has been found to be very effective as meeting the nutrient requirement by single source is not possible. For example, rice-wheat system requires around 30 t FYM/year to meet its nutrient demand. This can be very easily managed by adopting strategies of cropping systems involving green manures, legumes and combined application of FYM + vermicompost and neem cake. This type of management also helps in reducing the insect/disease incidences as incorporation of neem cake in soil has been found to much effective. FYM (partially composed dung, urine, bedding and straw), edible and non-edible oil cakes, enriched composts and effective microorganisms are some of the combinations which can be used for meeting the nutrient demand of crops. FYM contains approximately 5 - 6 kg nitrogen, 1.2 - 2.0 kg phosphorus and 5 - 6 kg potash per tonne. Though FYM is the most common organic manure in India, the farmer, in general, do not give adequate attention to the proper conservation and efficient use of the resource. For preparing better quality FYM, the use of pit method for areas with less than 1000 mm precipitation and heap method for other places is recommended. Some of the non-edible oilcakes such as castor and neem cakes are having the insecticidal properties also. Among the edible oil cakes, coconut, groundnut, niger, rapeseed and sesame cakes have higher nutrients (N ranging from 3 to 7.3 %; P_2O_5 ranging from 1.5 – 2 % and K_2O ranging from 1.2 to 1.8 %). In case of non-edible oil cakes such as castor, cotton, karanj, mahua, neem and safflower cakes, neem cake is having higher N (5.2 %), while castor and Mahua cake is having higher P_2O_5 (1.8 %) and K_2O (1.8 %) respectively. Depending upon the nature and quantity of raw material available with the farmer, any one or combination of composting methods such as Indore method, NADEP compost, NADEP phospho compost, IBS rapid compost, coirpith, sugarcane trash, pressmud composts, poultry waste compost using paddy straw, vermicompost, pitcher khad and bio-gas slurry can be adopted to make compost within the farm. Effective microorganism is a consortium culture of different effective microbes commonly occurring in nature. Most important among them are : N_2-fixers, P-solubilizers, photosynthetic microorganisms, lactic acid bacteria, yeasts, plant growth promoting rhizobacteria and various fungi and actinomycetes. In this consortium, each microorganism has its own beneficial role in nutrient cycling,

plant protection and soil health and fertility enrichment. Identified nutrient management packages for various cropping systems are given in Table 2.

Table 2. Identified nutrient management packages for cropping systems at different locations

Location (State)	Cropping System (s)	Sources to meet nutrients
Coimbatore (Tamil Nadu)	Cotton-maize-green manure (GM) Chillies-sunflower-greenmanure	Farm Yard Manure (FYM) + Non Edible Oil Cakes (NEOC) + Panchagavya (PG)
Raipur (Chhatisgarh)	Rice-chickpea	Enriched compost (EC) + FYM + NEOC + Bio dynamic (BD)+PG
Dharwad (Karnataka)	Groundnut-sorghum Maize-chickpea	EC + VC + Green leaf manure (GLM) + biodynamic and PG spray
Ludhiana (Punjab)	Maize-wheat-summer greengram	FYM + PG + BD in maize, FYM +PG in wheat and FYM alone in moong
Bhopal (Madhya Pradesh)	Soybean-wheat Soybean-chickpea Soybean-maize	FYM+PG + BD
Pantnagar (Uttarakhand)	Basmati rice-wheat-green manure Basmati rice-chickpea Basmati rice-vegetable pea	FYM + VC + NC + EC + BD + PG
Ranchi (Jharkhand)	Rice-wheat-green manure	VC+ Karanj cake + BD+ PG

B. Insect and disease management

In general, the incidence of pests and diseases are comparatively low under organic production system compared to inorganic systems due to several factors such as application of oil cakes having insecticidal properties, use of green leaf manures such as calotrophis and slightly higher content of phenols in plant parts under organic management. Further, organic management also increases the natural enemies in the farm. Natural enemies of crop pests and diseases such as Coccinellids, syrphids, spiders, Micromus, Chrysopa and campoletis were higher under organic management compared to integrated and inorganic management. Coccinellids, which naturally reduce the hoppers and leaf folders was found to be two to three times higher under organic management in cotton, groundnut, soybean, potato and maize crop fields (Table 3). Similarly, spiders which also control the pests are found to be twice higher under organic management compared to inorganic management. The diversity of arthropod population in soil viz., Collembola, dipluran, pseudoscorpians, cryptostigmatids and other mites population was also found to be higher under organic management compared to integrated and chemical management.

Table 3. Changes in *Coccinelids* and other natural enemy population in various crops under organic and chemical management practices

Crops	*Coccinelids*		Other natural enemies (*Syrphids, Micromus, Chrysopa, spiders*)		Cumulative % reduction of natural enemies/year under chemical management
	Chemical	Organic	Chemical	Organic	
Maize (nos/m)	0.80	2.65	0.50	1.53	68
Groundnut(nos/m)	0.69	2.58	0.76	2.15	69
Soybean (nos/m)	0.35	1.35	-	-	74
Cotton (nos/plant)	1.60	4.15	0.88	2.67	63
Potato (nos/m)	0.30	1.25	0.09	0.30	74

Products collected from the local farm, animals, plants and micro-organisms and prepared at the farm are allowed for control of pests and diseases. (eq. Neem Seed Kernel Extract, cow urine spray). The products that are permitted for control of pest & diseases are neem oil and other neem preparations like Neem Seed Kernel Extract, pheromone

Table 4. Identified pest and disease management packages at various locations for different cropping systems

Location (State)	Cropping System	Pest/disease	Recommended practice
Modipuram (Uttar Pradesh)	Basmati rice-chickpea	Soil borne pests and diseases	Summer ploughing + green manure incorporation
Calicut (Kerala)	Ginger	Shoot borer	Seed treatment with Ginger Endophytic Bacteria 17 & 18, Ginger Rhizobacteria 57
Bajaura (Himachal Pradesh)	Cauliflower-peas-tomato	Fruit borer & fruit rot	Karvi (*Roylea cinerea*) @ 10% aqueous leaf extract + cow urine (3%) + tween-80 (0.05%) as emulsifier
Umiam (Meghalaya)	Maize +Soybean	Monolapta Mylloceros Ephilechma Leaf folder	Derisom (3 ml/l) + Panchagavyya @ 10% and cow urine 3% Anomin 3 ml/litre or Panchagavyya @ 3%.
		Rust	Panchagavyya @ 3% + lantana @ 10% + vermiwash @ 10%

traps, mechanical traps, plant based repellants, Soft soap and clay. Identified pest & disease management packages for various cropping systems are given Table 4.

A popular natural pest repellent paste mixture prepared by Tamil Nadu farmers containing each 1kg leaves of *Vitex nigunda*, *Agave cantala* , *Datura metha*, *Calotropis* and neem seeds and dissolved in 5 litres of cow urine are kept in plastic or earthen ware. After 15 days of fermentation, 100 liters of water are added and the filtrate is sprayed in the field. It has been observed by farmers that most of the insect pests are repelled from the treated area.

C. Weed Management

Weeds are major problem under organic management and almost 43 % of organic growers expressed; low and no cost weed management techniques should be identified for successful practicing of organic farming. Slash weeding is to be done between the plants. Weeds under the base of the plants can be cleaned and put as mulch around the plant base. The weeded materials should be applied as mulch in the ground itself. Stale seed beds, hand and mechanical weeding are the other options available for managing weeds under organic management. Further, effective crop rotation, mixed and intercropping is also essential for reducing the weeds. Few identified weed management practices for various locations and cropping systems are given in Table 5.

Table 5. Identified weed management packages for various locations and cropping systems

Location (State)	Cropping System	Recommended practice
Raipur (Chhatisgarh)	Rice-mustard	Conoweeder with square planting for rice Stale seed bed for mustard
Coimbatore (Tamil Nadu)	Rice-blackgram-greenmanure	2 hand weeding + spray of aqueous leaf extract at 3-4 leaf stage of weeds
Dharwad (Karnataka)	Groundnut	Spray of *cassia* and *Prosppis juliflora* as post emergent
Ludhiana (Punjab)	Basmati rice-wheat-greenmanure	High density planting + hand weeding at 25-30 DAT
Pantnagar (Uttarakhand)	Basmati rice-wheat-*greenmanure*	one hand weeding at 25-30 DAT during *kharif* and 2 hand weeding at 25-30 and 45-50 DAS during *rabi*
Umiam (Meghalaya)	Maize (green cob)-mustard	Mulching with fresh eupatorium/ ambrosia @ 10 t/ha (after earthing up)

The other important practical constraints faced by organic growers are incidence of termites and rats. Some of the Indigenous Technical Knowledge (ITKs) practiced for termite management include application of dye prepared from Noni (*Morinda citrifolia*) mixed with garlic extract on trees, application of tank silt in sandy wetlands, *use of alotropis* plant material (8-10 kg) soaked in sufficient quantity of water for 24 hr and filtered and poured on termite infested soil and application of sheared human hair obtained from barber's shop, applied on live mounds and along the infested pathways.. ITKs used for rat management include pieces of cotton or thermocole, dipped in jaggery solution, made into small packets and spread in field / orchard and partly cooked sorghum grains coated with cement or white cement and packed into small packets and spread in the field.

Crop productivity and economics under organic management

Available records on grain yield of paddy under traditional farming practices indicates yield up to 2.95 t/ha (2605 lbs/acre) in the first crop (*Kuruvai*) and 2.81 t/ha (2484 lbs/ acre) in the second crop (*Thaladi*) [1925-26] has been recorded by Lalgudi Sivagnanam Co-operative Agricultural Society in the Madras Presidency.. Similarly in case of wheat, yield of 2.41 t/ha has been reported from West Bengal during 1970-71. Analysis of yield recorded at various locations under organic management over inorganic indicated many crops (Table 6) responded positively to yield higher under organic systems. Sustainable yield index of basmati rice, rice, cotton, soybean, sunflower, groundnut, lentil, cabbage and french bean are higher under organic management compared to integrated and inorganic management systems. Long-term results of organic management clearly establishes that the scientific Package of Practices (PoP's) for organic production of crops in cropping systems perspective should be adopted for keeping the crop productivity at comparable or higher level than chemical farming. Under ICAR-Network Project on Organic Farming (NPOF), location specific package of practices for organic production of crops in cropping systems (42 no's) suitable to 11 states have been developed which can be practiced for getting optimum productivity under organic management. Among the pulses, greengram, chickpea and cowpea responds better.

Organic production of basmati rice (PB-1)
(Source: NPOF centre, Pantnagar)

Table 6. Number of data entries, averages and ranges (%) of relative yields between organic over inorganic for selected crops in India

Crops	n[a]	Organic over inorganic		Crops	n[a]	Organic over inorganic	
		Mean	Range			Mean	Range
Basmati rice	67	104	88-121	Okra	10	118	90-142
Rice	52	100	89-122	Chilli	12	109	107-112
Maize	37	110	62-137	Onion	13	107	87-127
Sorghum	17	114	89-132	Garlic	9	104	86-121
Greengram	12	107	96-122	Cauliflower	12	104	90-117
Chickpea	24	100	65-114	Cabbage	5	111	81-142
Soybean	54	104	96-123	Tomato	11	106	83-130
Groundnut	16	103	83-116	Ginger	12	120	108-129

[a]n= the number of yield entries

Cost of production per unit area is comparable or less under organic agriculture than inorganic management when on-farm organic inputs are used. However, if organic inputs from outside the farm are purchased and utilized, the cost of production increases by about 13 %. Therefore, organic agriculture should naturally depend on on-farm generation of inputs including mixed cropping, crop rotation, residue recycling, composting etc.

Environment saviour: Continuous practice of raising the crops organically has good potential to sequester the C (up to 63 % higher C stock in 10 years), higher soil organic carbon (22 % increase in 6 years), reduction in energy requirement (by about 10-15 %) and increase in water holding capacity (by 15-20 %), thereby promoting climate resilience farming.

Chemical vs organically managed soil in the field (Source: NPOF centre, Ludhiana)

Summary

It can be concluded that scientific organic farming packages with ecological perspective needs to be maintained for obtaining comparable or higher yield of crops and income with that of chemical farming. Further, accelerated adoption of **“towards organic”** (integrated crop management) approach in intensive agricultural areas (food hubs) and **“certified organic farming”** with combination of tradition, innovation and science in the de-facto organic areas (hills) and rainfed/ dryland regions can contribute towards safe food security and climate resilience, besides increased income of farm households. This approach will also positively contribute to the cause of human, livestock and eco-system health, the basic objective of organic agriculture.

CHAPTER 2

Nutrient Management in Organic Farming: Principles and Practices

The management of nutrient in organic farming system is a challenge as the use of inorganic fertilizer which feed the plant directly and are thought to bypass the natural processes of the soil, is not permitted. Matching the nitrogen supply from the mineralization of organic materials, e.g., crop residues, green manure, composts and other organic sources, with the crop demand is difficult. In organic agriculture one view is the 'law of return' where it is considered essential that any nutrients removed in the crops or livestock must be returned to maintain fertility. Effective nutrient management is essential in organic farming systems. Nutrient supply to crop plants is supported through recycling, the management of biologically related processes such as nitrogen fixation and the limited use of unrefined, slowly soluble off- farm materials that decompose in the same way as soil minerals or organic matter. The carbon-to-nitrogen ratio (C: N) of a compost is one indication of the maturity and N availability. As the C: N ratio rises above 20:1, the tendency for N from the soil to be tied up increases. The organisms involved in the stabilization of organic matter utilize about 30 parts of carbon for each part of nitrogen and hence an initial C:N ratio of 30 is most favourable for composting. Research workers have reported the optimum value to range between 26-31 depending upon environmental conditions. In general, organic materials to be used as nutrient sources must have following specifications i.e. moisture should be 15-25 per cent by weight, colour –dark brown to black, absence of foul odour, particle size should be minimum (90 per cent material should pass through 4.0 mm IS sieve), bulk density should be <1 g/cc, total organic carbon should be minimum 2.0 per cent by weight, total N should be minimum 0.8 per cent by weight, total phosphates (P_2O_5) should be minimum 0.4 per cent by weight, total potash should be minimum 0.4 per cent by weight, C:N ratio must be < 20, pH should be 6.5 to 7.5, conductivity should not be more than 4.0 dS/m and there should be no pathogens. The heavy metal ranges can be upto a minimum of 10 ppm of arsenic, 5 ppm of cadmium, 50 ppm of chromium, 300 ppm of copper, 0.15 ppm of mercury, 50 ppm of nickel, 100 ppm of lead and 1000 ppm of zinc. (www.ncof.dacnet.in). Overall, a sum total of nitrogen, phosphorus and potassium nutrients shall not be less than 1.5 per cent in city compost and shall not be less than 2.5 per cent in case of vermicompost.

A number of approved organic fertilizers or natural materials are available commercially. Many of these materials are by-products of fish, meat, and soybean processing industries. The commercial formulations and nutrient analyses of these materials vary considerably. In general, they range from 1 to 12 per cent N and provide P, K, or both along with N. Other simple fertilizer materials that offer only one macronutrient including blood meal (N), rock phosphate (P), potassium sulfate (mined; K) and green sand (K). Certain by-products of the meat processing industry, such as blood and bone meal, have recently come under scrutiny because of food safety concerns and the potential for disease transmission.

Organic fertilizer sources commonly contain one or more minor elements. Additional synthetic fertilizers may be permitted by a certifying agency in specific circumstances for correction of minor element deficiencies such as zinc or copper deficiency. Application of approved source materials will raise soil levels to a range where they are not deficient. In the present time, zinc deficiency may appear and it must be corrected by spraying $Zn\ SO_4$ @ 0.5% (5kg $ZnSO_4$ and 2.5 Kg lime in 1000 L of water per hectare) is recommended.

Specific approved nutrient sources of K, Ca, and Mg may be useful to an organic grower when a deficiency or imbalance is indicated by a soil test. Materials such as gypsum, lime, and potassium-magnesium sulfate have been in use in agriculture for many years and their value is thoroughly tested. These materials may be used to correct deficiencies or imbalances of potassium, calcium, or magnesium, and lime may be used to raise soil pH. Gypsum also is often applied to replace exchangeable sodium prior to leaching a high-sodium soil (usar land) or to improve water infiltration on clay soils with poor structure. Pyrites may also be used as amendment for sodic soils. Materials derived from kelp and other processed seaweed contains nutrients and often plant hormones and growth regulators. Some claim that microbial soil stimulants enhance growth or reduce soil pests.

Nutrient Sources

Crop rotations are the key techniques for managing overall nutrient supply on organic farms. Crop diversification can deliver many agronomic and ecological benefits simultaneously, while maintaining or enhancing efficiency of production. Growing of cover crops and green manure crops that includes N-fixing legume is the most economical way to provide N to a succeeding crops and also reduce nitrate leaching, nutrient runoff, and soil erosion. Typically, a green manure crop will require approximately 50 to 60 days of growth to fix between 60 and 90 kg N per ha. Compost, vermicompost and other enriched composts are the relatively cost-effective organic source of N. These composts also provides P, K, Ca, Mg, S, and other minor nutrients in fairly well-balanced amounts. Although actual concentrations of P and K in composts are low, the total additions may be quite high due to the high volume of material applied. Nutrient sources commonly used for organic farming are green manure, farm yard manure (FYM), vermicompost (VC), compost, enriched compost, bio-gas slurry, non-edible oil cakes, poultry manure, Azolla, biofertilizer, biodynamic compost and *Panchgavya*.

(A) Green Manure: Green manures, often known as cover crops, are plants which are grown to improve the structure, organic matter content of the soil. They are a cheap alternative to artificial fertilizers and can be used to compliment animal manures. Growing a green manure is not the same as simply growing a legume crop, such as beans, in a rotation. Green manures are usually dug into the soil when the plants are still young, before they produce any crop and often before they flower. They are grown for their green leafy material which is high in nutrients and provides soil cover with view to increase organic matter and humus content in the soil. The crops to be taken for green manuring should be fast growing, rich in nutrient like legumes, resistant to biotic and abiotic stresses, has smoothening effect against weeds and with more foliage. Crops that are commonly used for green manuring are *Sesbania aculeata* (suitable for rice-wheat, 55 days old crop producing 17-30 tonnes green matter per ha), *Sesbania speciosa* (suitable for wet lands, when raised on field borders along the bunds, 90 day old crop contributes 2-4 tonnes green matter per ha) and *Crotolaria juncea* (suited to almost all parts of country and adds 15-25 tonnes fresh biomass in 50-60 days). They can be grown together with crops or alone. Because the C:N ratio of green manure crops increases as they age, it is generally recommended that green manure crops be harvested or incorporated into the soil when close to full bloom (but prior to seed set) to assure a C:N ratio of 22:1 or less so that net mineralization occurs.

Green manure and its incorporation - a pre requisite for organic farming

Green manure crops generally used are *Sesbania aculeata* and *Crotalaria juncea*. A seed rate of 25-30 kg per ha of *Sesbania* and *Crotalaria* should be used for raising green manure. Generally broadcasting of green manure seeds is practiced. However, better green manure crop can be raised if line sowing is adopted at 45 cm row spacing. One pre-sowing irrigation should be applied with 1-2 irrigations in between green manure crop depending on summer rains, sufficient for growth of green manure crop. Sowing is usually done in last week of April to first fortnight of May. The green manure crop to be turned down around 55-60 days after sowing. The *Trichoderma* (10 g per litre) should be sprayed on turned *Sesbania/Crotalaria* crop in the field before puddling and transplanting rice crop. The 60-day-old crop can contribute approximately 100 kg N/ha, 25-30 kg P_2O_5/ha and 75 kg K_2O/ha and these can meet the requirement of organic rice crop (Chandra, 2005).

Indigenous FYM Production Technology

(B) Farm Yard Manure (FYM): Farm yard manure is partially decomposed dung, urine, bedding and straw. Dung comes mostly as undigested material and urine from digested material. More than 50 per cent of the organic matter that is present in dung is in the form of complex products consists of lignin & protein which are resistant to further decomposition and therefore the nutrients present in dung are released very slowly. The nutrients from urine become readily available. Dung contains about 50 per cent of the nitrogen, 15 percent of potash and almost all of the phosphorus that is excreted by animals.

On an average, about 3-5 kg bedding material per animal is used by farmers. FYM contains approximately 5-6 kg nitrogen, 1.2 to 2.0 kg phosphorus and 5-6 kg potash per tonne. If properly preserved, the quantity of manure that can be produced per animal per year would be as much as four to five tonnes containing 0.5 per cent nitrogen. If available, well decomposed FYM should be applied @15-20 tonnes per ha for cereals and 5-10 tonnes per ha for pulses, which can supply about 75-100kg N per ha, 35-40 kg P_2O_5/ha and 75-100 kg K_2O per ha. FYM should be decomposed by adding *Trichoderma* powder.

(C) Vermicompost: Vermicomposting is a simple biotechnological process of composting in which certain species of earthworms enhance the process of waste conversion and produce a better end product *i.e* vermicompost. The worm castings (vermicompost) contain higher percentage (nearly twofold) of both macro and micronutrients and it is evident that vermicompost provides all nutrients in readily available form and also enhances uptake of nutrients by plants. Vermicomposting converts household compost within 30 days, reduces the C: N ratio and retains more N than traditional method of preparing compost. Vermicomposting can be done by using several methods *viz.,* pits below the ground, heaping above the ground, tanks above the ground and cement rings. Among these methods, considering bio-degradation of waste as the criterion, the heap method of preparing vermicompost was better and earthworm population and biomass production and consequently vermicompost production was also higher. The African species of earthworms, *Eisenia foetida* and *Eudrilus eugenae* are ideal for the preparation of vermicompost and earthworms should be protected against birds, termites ants & rats and plant based materials such as grass, leaves or vegetable peelings should be utilized in preparing vermicompost (Nagavallemma *et al*., 2004). For the preparation of vermicompost, pits are made of 1 m deep and 1.5m wide, however, the length varies as required and bottom of the

Earthworms and vermicompost production

pit is covered by polythene sheet on which 15-20 cm layer of organic waste material (it helps in improving nutritional quality of compost) and finally cow dung slurry should be sprinkled. Culture of *Pseudomonas fluorescens* may also be added (@ 200g/100kg). Pit is filled completely in layers as described and finally the top of the pit is pasted with soil or cow dung and material is allowed to decompose for 15-20 days. During the decomposition of the materials has subsided (15-20 days after heaping). Selected earthworms (500 to 700) were released through cracks and water is sprinkled every three days to maintain adequate moisture. Vermicompost is ready in about 2 months if agriculture waste is used. When compost is ready water should not be allowed for 2-3 days and compost is piled in small heaps and left under ambient conditions for a couple of hours when all earthworms move down the heap in bed and finally upper portion of the manure is sieved from lower portion to separate earthworm from manure. This processed vermicompost is black, light in weight and free from bad odour.

(D) Compost: Compost is organic matter (plant and animal residues) which has been rotted down by the action of bacteria and other organisms, over a period of time. The biodegradation process is carried out by different groups of heterotrophic microorganisms like bacteria, fungi and actinomycetes etc. Organic materials undergo intensive decomposition under thermophilic and mesophilic conditions in heap, pits or tanks with adequate moisture and aeration and finally yield a brown to dark brown coloured humified material called compost. Materials such as leaves, fruit skins and animal manures can be used to make compost. Compost is cheap, easy to make and is a very effective material that can be added to the soil, to improve soil and crop quality and also improves the structure of the soil. This allows more air into the soil, improves drainage and reduces erosion. Compost improves soil fertility by adding nutrients and by making it easier for plants to take up the nutrients already in the soil which produces better yields.

C:N ratio affects the rate of decomposition of compost. Low C: N ratio (below 25:1) may result in too rapid decomposition and the loss of nitrogen in the form of ammonia. A C: N ratio that is too high may result in too long a decomposition process and a low quality end product. Ideal C: N ratio range is 25:1 to 40: 1. The moisture of decomposing organic material should be maintained around 50-55 per cent (www.uvm.edu).

(E) Enrichment of compost: Various methods of composting for nutrients enrichment through rock phosphate, pyrite and micro-organism have better quality with respect to N, P, K and S content. For enriching the compost with rockphosphate, rockphosphate is added at the rate of 12.5 per cent in a mixture of plant residue+ FYM+ soil in ratio of 8: 1.0: 0.5 in the form of slurry on plant residue during composting. Likewise, for enriching the compost with pyrite, pyrite is added at the rate of 10 per cent in a mixture of plant residue+ FYM+ soil in ratio of 8: 1.0: 0.5 in the form of slurry on plant residue during composting. While for enriching the compost with inoculums, a mixture of FYM (10 kg) + soil (2kg) + inoculums (1 kg *Azotobacter* + 1 kg PSB + Pseudomonas + 1 kg Thiobacillus + 1kg Beauveria + 1 kg Pant biocontrol agent 1, 2 & 3) in a 100-150 litre of water was added on the top of layer while composting which is sufficient for 1 ton of enriched compost.

Enriched Compost Preparation

Bio-gas slurry

(F) Bio-gas slurry: Bio-gas slurry is a good source of organic manure. Anaerobic digestion of raw animal dung by microbes in the bio gas plant offers more advantages in improving the manorial value of the slurry as compared to the manorial product of aerobic decomposition. An aerobic decomposition of organic matter results in about 30 to 50 per cent loss of nitrogen, whereas there is almost complete conservation of nitrogen in anaerobic digestion. During anaerobic bio-digestion, about 15 to 18 per cent of total nitrogen is converted into ammonical nitrogen as main source of soluble nitrogen. It is therefore, necessary to take precaution for proper storage of slurry and also during its application to soil to reduce the loss of ammonical nitrogen. All chemical elements except carbon, oxygen, hydrogen and sulphur contained in animal dung are conserved in bio-digested slurry which is reported to be rich in plant nutrients both macro & micro nutrients compared to FYM. Air dried bio gas slurry can be applied by spreading on the agricultural land at least one week before sowing the seed or transplanting the seedlings. Nutrient content of Bio-gas slurry approximately 1.43 per cent N, 1.21 per cent P and 1.01 per cent K on dry weight basis. In general, 10 tonnes per ha bio-digested slurry is recommended to be applied once in three years to maintain organic content in soil, beside providing nitrogen, phosphorus and potassium in form of organic fertilizers to the crop(www.ncof.dacnet.in).

(G) Non-edible oil cakes: Non-edible oil cakes have higher nutrient content as compared to other organic manures. Many oil cakes such as castor, neem, mandus, karanja, linseed, rapeseed and cotton seed may serve as good organic source. Neem cake contains the alkaloids-nimbin and nimbicidine which effectively inhibits the nitrification process and increasing the yield, nitrogen uptake and grain protein content of rice. Mahua cake has been successfully used in coastal saline soils for cultivation of rice. They are insoluble in water but their N become quickly available to plants about a week or 10 days after application. Most of the non-edible oil cakes are valued much for their alkaloid contents which inhibit the nitrification process in soils. Commonly available non-edible oil cakes used as organic nutrient and their nutrient content is presented in Table 1.

Table 1. Non-edible oil cakes and their nutrient content

Oil cakes	N (%)	P_2O_5 (%)	K_2O (%)
Groundnut cakes	7.3	1.53	1.33
Linseed cakes	5.6	1.44	1.28
Castor cakes	4.4	1.85	1.39
Neem cakes	5.2	1.08	1.48

(H) Poultry manure: Poultry waste comprises waste feed, solid and liquid dropping, litter, eggshell, diseased and dead birds, culled birds, feathers and the wastes from poultry sheds. Poultry manure is concentrated organic manure used as a nutrient source in organic farming particularly for vegetables comprising of 2.9 per cent nitrogen, 2.9 per cent phosphorus and 2.4 per cent potash. Broiler litter also contains 23-125 ppm copper, 125-667 ppm manganese and 106-669 ppm zinc. Poultry waste manure is highly complex and challenging because of associated problems like nitrate and heavy metal contamination in soil, crops, surface and ground water, air quality and odour, disposal of dead and diseased poultry and food safety.

(I) Azolla: Inoculation of Azolla bio-fertilizer at 7 days after transplanting of rice crop @ 2 tonnes per ha in standing water and its growth during the rice crop adds organic matter and nitrogen to the soil. The Azolla incorporation at the time of puddling of rice soil @ 6tonnes per ha can also provide about 25-30 kg N per ha to the rice crop in organic farming system. For Azolla incorporation we need to produce required amount of biomass in multiplication tanks/ponds.

Mass production of Azolla

(J) Biofertilizers: Biofertilizers means the product containing carrier based (soild or liquid) living microorganisms which are agriculturally useful in terms of nitrogen fixation, phosphorus solubilization or nutrient mobilization to increase productivity of the soil and/or crop. Biofertilizers are live materials hence should be handled carefully and a favourable environment in the field should be assured for desired results. To ensure good quality biofertilizer, formulation should be carrier based or liquid formulation capable of holding very high population of specific microorganisms for sizable period of time. In case of carrier based formulations, the product should have 30-50 per cent of moisture throughout the shelf life period to sustain microbial population and the microbial population should be in the range of 10^7 to 10^9 cells/g of moist product. In case of liquid formulations, the cell load should be in the range of 1×10^8 to 1×10^{10} during the entire period of shelf life. In addition to this, it should be free from other contaminating microorganisms and should have sufficient shelf life (minimum 6 months for carrier based and 12 months for liquid) (www.ncof.dacnet.in). Three types of biofertilizers are used i.e. Symbiotic N_2 fixers such as *Rhizobium* culture for legumes; free living N_2 fixers (non-

Table 2. Rate and method of application of *Azotobacter, Acetobacter, Azospirillum/* Phosphotica biofertilizers

S. N.	Method of use	Crop	Rate of application
1.	**Seed treatment** Dissolve required amount of biofertilizer in one litre of water and slowly spread the solution on the seeds and mixed by the hand till the seeds are coated with uniform layer of biofertilizer. Dry the seeds in the shade and cover the seeds with soil after sowing the seeds in the furrow.	Wheat, Maize, Sunflower, Mustard, Toria, Seasmum, Okra, Pearl Millets, etc.	One packet (200g) for 10 kg of seeds
2.	**Root treatment of seedling** Dissolve required amount of biofertilizer in the bucket or tub having (1 kg) in 4 to 5 litres water. Dip the roots of seedling in the solution for 10 minutes.	Rice, Chilli, Tomato, Cabbage, Cauliflower, Capsicum, Apple, Pear, Peach, Apricot, Pearl Millets	1.5 to 2 kg/ha
3.	**Tuber treatment** Dissolve required amount of biofertilizer (2 kg) in 15 litres of water and dip the tubers in the solution for 5 to 10 min or equally spread the solution on the tuber and sow in the field.	Potato, Ginger, Turmeric, etc.	2 to 2.5 kg/ha
4.	**Soil treatment**Mix required amount of biofertilizers in 40-50 kg compost or fine soil and broadcast just after the last harrowing or before the first irrigation in one acre area.	Suitable for long duration crops	3 kg/ha
5.	**Blue green algae (BGA)**Apply 10-12 kg BGA before one week of transplanting of rice for one hectare. 3-4 cm standing water is required at the time of application. If any herbicides are used in the rice, apply BGA 3-4 days before the herbicide application.	Rice	10-12 kg/ha

symbiotic bacteria) such as *Azotobacter* and *Azospirillum* spp. for cereals, blue green algae and Azolla for rice and P solubilizers such as *Pseudomonas* sp. While symbiotic N_2 fixers inoculated in legumes can fix substantial amount of atmospheric N_2 to feed the host plant, free-living N_2 fixers contribute much less, usually 10-30 kg/ha. P solubilizers enhance the availability of native inorganic P.

(K) Biodynamic Compost (BD): The (biodynamic- energy) means working with the energies which create & maintain life. Biodynamic is not organic because biodynamic preparations do not contain plant nutrients and are required in very small quantities after energizing and many fold dilutions. There are eight known biodynamic composts, namely biodynamic preparation (BD) 500(Cow horn manure), 501 (Horn silica), 502 (Yarrow), 503 (Chamobile), 504 (Stinging nettle), 505 (Oak bark), 506 (Dandelion), and 507 (Valerian) and Cow-Pat Pit (CPP). These preparations are easy to formulate and can be done by farmers at their own farms. Out of these, formulation-500 (Cow-horn compost) and formulation-501 (horn silica) can be used directly in soil and plants. These BDs are very popular and are being used by large number of organic farmers. Formulation 502 to 507 is compost enrichers and promoters, while formulation 508 is of prophylactic in nature and helps in control of fungal diseases (Steiner, 1974).

BD-500 (Cow- horn manure) usually increases humus in soil and after dilution in water, it is sprayed directly on land during early spring (March-April) and autumn September-early October) concentration 30-35 gms in 12 litres of boiled cool water and stirred for 1 hour in the evening before sowing or transplanting. Mixing of *PSM, Azotobacter, Azospirillium* and *Bacillus subtilis* 100 ml each in solution ensures better yield in all crops. BD-501 (Horn silica) increases photosynthesis and after dilution in water, it is sprayed directly on acres land during early spring October, concentration 30-35 g in 12 litres of boiled cool water and stirred for 1 hour in the evening before sowing or transplanting. Mixing of *PSM, Azotobacter, Azospirillium and Bacillus subtilis* 100 ml each in solution ensures better yield in all leafy crops like tea, cabbage, spinach, etc. BD-502 (Yarrow) increases metabolic activity in soil and fter dilution in in water, it is sprayed directly in one acre land during concentration 30-45 grams in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting. Mixing of PSM, *Azotobacter, Azospirillium and Bacillus subtilis* 100 ml each in solution ensures better yield in all crops. BD-503(Chamobile) conditions the soil and after dilution in water, it is sprayed directly in one acre land at concentration 40-50g in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting. *Mixing of PSM, Azotobacter, Azospirillium and Bacillus subtilis* 100 ml each in solution ensures better yield in all crops. BD-504(Stinging nettle) increases N-fixing bacteria activity and after dilution in water, it is sprayed directly in one acre at concentration of 50g in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting. BD-505 (Oak Bark) acts as NPK enricher in soil and used for disease resistance, after dilution in water, it is sprayed directly in one acre land at concentration of 50g in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting. BD-506 (Dandelion) after dilution in water, is sprayed directly in one acre land at a concentration of 50g in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting. BD-507 (Valerian) acts as compost enricher and after dilution in water, it is sprayed directly in one acres land during winter, at a concentration of 30-35g in 12 litres of water of boiled cool water and stirred for one hour in the evening before sowing or transplanting. BD-508 after dilution in water is sprayed in one acre land during winter at a concentration of 30-35g in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.

CPP can be used in various ways depending upon the requirement and crop/plants. CPP can be used @ 100g per acre mixed with BD 500 or 501 as spray. CPP can be used as soil inoculants (@ 2kg per acre) mixed with composts. CPP can also be used as foliar spray (@ 5 kg per acre) right from the beginning of crop upto fruit/ pod formation stage with an interval of 7 to 15 days. CPP can also be used as paste on stem of fruit trees. CPP can also be used as inoculant to biodynamic composts in place of 502 to 507 (www.ncof.dacnet.in).

(L) *Panchgavya:* *Panchgavya*, an organic product has the potential to play the role of promoting growth and also provides immunity in plant system. Physico-chemical properties of *Panchgavya* revealed that they posess almost all the major nutrients, micronutrients and growth hormones (IAA and GA) required for crop growth. Predominance of fermentative microorganisms like yeast and lactobacillus

***Panchgavya* preparation**

might be due to the combined effect of low pH, milk products and addition of jaggery/ sugarcane juice as substrate for their growth (www.agritech.tnau.ac.in). *Panchgavya* consists of nine products *viz.,* cow dung, cow urine, milk, curd, jaggery, ghee, banana, tender coconut and water. When suitably mixed and used, these have miraculous effects. Here for its preparation, the product of local breeds of cow is said to have potency than exotic breeds. For this mix 7 kg cow dung and 1 kg cow ghee thoroughly both in morning and evening hours and keep it for 3 days. After 3 days mix 10 litres of cow urine and 10 litres of water and keep it for 15 days with regular mixing both in morning and evening hours. After 15 days mix cow milk-3 litres, cow curd- 2 litres, tender coconut water – 3 litres, jiggery- 3 kg and well ripened poovan banana-12 nos. and Panchgavya will be ready after 30 days. All the above items can be added to a wide mouthed mud pot, concrete tank or plastic can as per the above order. The container should be kept open under shade and covered with a wire mesh or plastic mosquito net to prevent house flies from laying eggs and formation of maggots in the solution.

Panchgavya is sprayed on crops at a concentration of 3 per cent (3 litres *panchgavya* to every 100 litre of water is ideal for all crops). The solution of *panchgavya* can be mixed with irrigation water at 50 litres per hectare either through drip irrigation or flow irrigation. Also, 3 per cent solution of *panchgavya* can be used to soak the seeds or dip the seedlings (20 minutes before transplanting). Rhizomes of turmeric, ginger and sets of sugarcane can be soaked for 30 minutes before planting. *Panchgavya* is used at pre-flowering phase (once in 15 days, 2 sprays depending on duration of crop), flowering and pod setting stage (once in 10 days, 2 sprays) and fruit/ pod maturation stage (once during pod maturation).

Nutrient Application and Management Aspect

For nutrient management aspect, nutrient release pattern of organic materials which depend on C: N ratio of source, soil type, temperature and climatic conditions that must be coincided with seasonal/ temporal nutrient requirement of the crops.

- Inclusion of legumes/green manure initially at least for 2-3 years are necessary to maintain the soil fertility and productivity of crops. After conversion of 3-4 years, wheat or mustard crop can be taken as succeeding crop.
- Green mannuring (GM) before rice/*kharif* crop has been observed to be the best source of nutrients for organic farming. After incorporation of green manure crop,

25 kg N should be given through Vermicompost (2.5 t/ha approximately) as top-dressing just before the first hand weeding for initially 2-3 years; after three years only *in-situ Sesbania* green manuring is sufficient to fulfill nutritional requirement of basmati rice.

- If it is not possible to include *Sesbania* as green manure in the system, then FYM @ 20 t/ha or vermicompost @ 10 t /ha for rice, wheat, mustard and potato crops and FYM @ 10 t/ha or vermicompost @ 5t/ha for pulses and small millets is recommended.
- For fruit trees, the amount of vermicompost ranges from 5-10 kg per tree depending on age of the plant. For raising seedlings to be transplanted, vermicompost at 1 tonne per hectare is applied in nursery bed, but for transplants, vermicompost at the rate of 400-500 g per plant is applied initially at the time of planting and 45 days after planting (before irrigation).
- For flowers, vermicompost is applied at 750-1000 kg per ha.
- Application of 25 kg FYM or 15 kg vermicompost/10 m^2 is recommended for raising paddy nursery. In addition to this, if zinc deficiency is observed in nursery, 2 sprays of $ZnSO_4$ (0.5%) + lime (0.25%) in water at 10 and 20 days after sowing is recommended. Spray of $ZnSO_4$ can be more effective with five time diluted vermi-wash or 10% cow urine.
- Integrated application of FYM + Vermicompost + Enriched compost + Neem cake (¼+¼+¼+¼ on the basis of recommended dose of N only) or FYM + Vermicompost ($^1/_2$ + $^1/_2$ on the basis of recommended dose of N) found better as compared to single organic source. Application of FYM and enriched compost as basal and vermicompost and neem cake as top dressing at 20-25 days after transplanting to rice crop and whole dose of nutrient as basal to wheat and other *rabi* crops performed well. Soil application of neem cake @ 5q/ha, besides supply of nutrients, also protects the plant from soil-borne diseases and its continuous use prevents the infestation of termites.
- The dosage of organic manures (FYM/Compost/Vermicompot) can reduced by 25% fortified (incubated for one week prior to application) with *Trichoderma*, *Pseudomonas*, PSB (Phosphorus solubilizing bacteria), *Azotobacter*, *Azospirillum* and other Plant Growth Promoting Rhizobacteria (PGPR) which will not only enhance

the mineralization process and availability of nutrients but also protect the plants from several soil borne diseases. The dosage of bio-fertilizers/bioinoculants should be used @ 1kg/q manure.

- It is also known and observed that regular use of organic manure can postpone deficiency of zinc and other trace elements in soils, where high yielding varieties are grown.

References

Chandra, K. 2005. Organic Manures. In: Proceedings of Training programme on Production & Quality Control of Organic Inputs., Regional Centre of Organic Farming, Bangalore-24.pp 1-45.

Nagavallema, K.P., Wani, S.P., Stephane Lacroix., Padmaja,V.V., Vineeta, C., Babu Rao, M and Sahrawat, K.L. 2004. Vermicomposting: Recycling wastes into valuable organic fertilizer, Global Theme on Agroeosystem report no. 8. Patencheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 20pp.

Steiner, R. 1974. *Agriculture: A course of 8 lectures.* Bio-dynamic Agriculture Association., London

http://www.uvm.edu/utvegandberry/factsheets/organicN.html

http://www.ncof.dacnet.in

http://www.agritech.tnau.ac.in

CHAPTER 3

Weed Management in Organic Farming

Weeds constitute a special class of pests which seriously limit the production of the crops on any scale. They compete with the crops for nutrients, air, light and moisture and play major roles in crop yield loses (Ofor*et al*., 2009; Kumar *et al.,*2013; Das et al., 2016). In a review of crop yield losses due to pests, it was reported that: 'overall, weeds caused the highest loss (34%) with animal pests and plant pathogens being less important causing losses of 18% and 16%, respectively (Oerke, 2005). The losses caused by weeds exceed the losses from any other category of agricultural pests (Sharma *et al.,*2010). Minimizing loses due to weeds, pests and diseases necessitate farmers' choice of synthetic chemical use has several adverse effects on the environment and human health (Oruonye and Okrikata, 2010). Herbicides accounted for 46% of global pesticide sales in 2005, with insecticides (26%) and fungicides (23%) accounting for smaller proportions of total spending (Agrow, 2006). While herbicides are considered the main means of weed control in many countries of the world, there is increasing recognition that non-chemical methods of weed control have numerous advantages both for man and his environment (Bond *et al*., 2003). Non-chemical weed control methods Are advocated for the purposes of environmental health, human health and avoidance of weeds resistant to herbicides (Ofuoku *et al*., 2008).

Our perceptions of what a weed is will vary based on location, plant species, population size, and other factors. On a farm, weeds are those plants that negatively affect crop production. First and foremost, weeds compete with crops for resources, such as light, nutrients, and water, and potentially reduce crop yields. Weeds also lead to increased production costs — the costs of controlling them and the insects and diseases they harbor. During harvest, weeds can interfere with machinery and further reduce crop quality through contamination. Despite the lack of a clear definition for every circumstance, plants that fall into the weed category have shared characteristics that earn them the "weedy" distinction. Weeds can scavenge and compete for resources, and they respond rapidly to favorable growing conditions.

Furthermore, weeds have several characteristics that enhance reproductive capability:

- They reproduce via seeds, vegetative propagation, or both.
- They exploit different mechanisms for seed dispersal.
- A single propagule is enough to start a sexually reproducing colony of plants.
- They produce a great number of seeds. Examples of species that produce a great number of seeds per plant include redroot pigweed (*Amaranthus retroflexus*, 117,000 seeds per plant), common purslane (*Portulaca oleracea*, 52,000), common lambsquarters (*Chenopodium album*, 28,000) (Finney and Creamer, 2008)

Weeds have many attributes undesirable to crop producers, not the least being the ability to reduce crop yields through competition for resources such as sunlight, water, nutrients, and space. Weeds also may harbor insects and provide a host for certain plant pathogens. Some weed species, such as wild garlic and eastern black nightshade, can reduce the quality of the harvested crop.

Economical crop production is not possible under organic farming without well-planned weed management strategies. Competition occurs when one of the resources (nutrients, light, moisture and space) fall short of total requirement of both economic crops and weeds. Weeds by virtue of their nature grow faster and dominate the crop habitat and reduce the yield potential of most of the cultivated crops.

Eliminating or reducing the deleterious effects of weeds on crops is the ultimate goal of weed management. Integrated weed management (IWM) includes all practices that enhance a crop's competitive ability and decrease weeds' ability to reduce yield (Finney and Creamer, 2008).Today, there is a renewed interest in organic methods of managing weeds since the widespread use of agro-chemicals has resulted in purported environment and health problems. It has also been found that in some cases herbicides use can cause some weed species to dominate fields because the weeds develop resistance to herbicides. In addition, some herbicides are capable of destroying weeds that are harmless to crops, resulting in a potential decrease in biodiversity. It is important to understand that under an organic system, weeds will never be eliminated but only managed.

Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. Organic farming” is defined as production system which avoids or largely excludes the use of synthetically compounded fertilizer, pesticides, growth regulators and livestock feed additives. The green revolution technologies involving indiscriminate use of synthetic agrochemicals such as fertilizers and pesticides with adoption of nutrient responsive high yielding varieties of crop have boosted the production. Of late, concern has been raised time and again over its adverse effect on degradation of soil and environment. These are soil erosion, depletion of organic matter in soil, low water availability, contamination of food and water due to agrochemicals and also adverse effect on biodiversity. Hence, there is an urgent need to minimize the environmental degradation as much as possible and restore the productivity of degraded soils. Organic farming is one of the options to achieve this goal.

In an weed management approach under organic system, the central goal is to reduce weed competition and reproduction to a level that the farmer can accept. In many cases, this will not completely eliminate all weeds. Weed management should, however, reduce competition from current and future weeds by preventing the production of weed seeds and perennial propagules - the parts of a plant that can produce a new plant. Consistent weed management can reduce the costs of weed control and contribute to an economical crop production system.

Methods of weed management

Weed management within an organic farm relies on an integrated cropping-system approach. An organic farming system should be designed to create a balance between crop plants and weeds. Within such a system, farmers can take action to tip the balance in favor of crop plants whenever possible:

A. Cultural practices

1. Crop Rotation

Organic farmers often use mixed cropping systems and long rotations to enhance soil fertility and economic diversity. Crop rotation also can be a cornerstone in a weed management plan. Crop rotation involves alternating different crops in a systematic sequence on the same land. It is an important strategy for developing a sound long term weed control program. Weeds tend to thrive with crops of similar growth requirements as their own and cultural practices designed to contribute to the crop may also benefit the growth and development of weeds. Monoculture, that is growing the same crop in the same field year after year, results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, etc.).

- When a crop with a dense, closed canopy, such as potatoes, is grown prior to growing a crop that is less competitive with weeds, the dense crop reduces the development of weeds.
- Where late-germinating weeds are a concern, an early crop can be followed with tillage and a vigorous, competitive summer annual crop to suppress these weeds.

2. Cover Crops

Rapid development and dense ground covering by the crop suppress weeds. The inclusion of cover crops such as ricebean, groundnut, rye, red, clover, buckwheat, wintering crops like winter wheat or forages in the cropping system can suppress weed growth. Highly competitive crops may be grown as short duration 'smother' crops within the rotation. Cover crops offer many benefits to an organic farming system, including protection against soil erosion,improvement of soil structure, soil fertility enhancement, and weed suppression. Covercrops can be used in a variety of ways to suppress weeds. Cover crops can suppress weeds, reduce weed populations in the subsequent crop, and reduce weed seed contributions to the soil seedbank:

- Annual or short-term perennial cover crops can be used in place of a fallow period to reduce soil erosion and maintain soil fertility while competing with weeds for resources, such as light, water, and nutrients.

- Cover crops that develop rapidly and form a dense canopy can keep sunlight from newly emerged weeds and outcompete them.
- Cover crops can also provide organic mulch or act as a living mulch to further suppress weed populations during the cropping season.

3. Intercropping

Intercropping involves growing a smother crop between rows of the main crop. Intercrops are able to suppress weeds. However, the use of intercropping as a strategy for seed control should be approached carefully. The intercrops can greatly reduce the yields of the main crop if competition for water or nutrients occurs. Intercropping of soybean and groundnut in upland rice, maize or sorghum greatly reduces the weed problem.

Rice+groundnut (4:2) intercropping

4. Field Scouting

It involves the systematic collection of weed and crop data from the field (weed distribution, growth stage, population, crop stage etc.). The information is used, in the short term, to make immediate weed management decisions to reduce or avoid economic crop loss. In the long term, field scouting is important in evaluating the success or failure of weed management programs and for making sound decisions in the future.

5. Mulching

Applying mulch after planting can offer some benefits in many cropping systems. Mulches reduce weed competition by limiting light penetration and altering soil moisture and temperature cycles.

Living mulch: Living mulch is usually a plant species that grows densely and low to the ground such as clover. Living mulches can be planted before or after a crop is established. It is important to kill, or manage living mulch so that it does not compete with the actual crop. A living mulch of *Portulaca oleracea* from broadcast before transplanting broccoli can suppress weeds without affecting crop yield. Often, the primary purpose of living mulch is to improve soil structure, aid fertility or reduce pest problems and weed suppression may be merely an added benefit.

Organic Mulches: Organic mulches include many materials that can be produced on-farm such as hay, straw, grass mulch, crop residues, and livestock or poultry bedding. Other materials, such as leaves, composted municipal wastes, bark, and wood chips, may be available from off-farm sources. Farmers must consider both the quantity and type of mulch to be applied, and the cost of the mulch and the equipment needed to manage it.

Cost: In situations that require hauling and applying organic mulches, the use of organic mulches can be cost-prohibitive for farmers. Farmers can reduce the costs of purchasing, hauling, and applying mulch by using these strategies:

- Investigate locally available organic mulches. Municipalities will often deliver organic materials for free because it saves them landfill costs. However, its quality interms of contamination from heavy metals, microbial load etc. should be considered.
- Investigate ways in which mulches can be produced on-farm.
- Have organic mulch materials analyzed for both nutrient concentration and potential contaminants such as heavy metals, especially those procured off-farm.

Benefits and drawbacks: Using organic materials as mulch can help to increase soil organic matter, promote soil biological activity, and enhance soil structure, water infiltration, and aggregate stability. Organic matter is biodegradable and does not contribute to landfill problems. Despite these advantages, however, several drawbacks must be considered:

- Organic mulches high in carbon may temporarily reduce the availability of soil mineral nitrogen as they decompose.
- Allelopathic interactions between mulch materials and the crop are possible.
- Mulches of any type may delay soil warming early in the season. Delayed warming can slow or reduce germination of annually seeded crops or lead to delayed fruit set and harvest in perennial systems. Delaying mulching until two to four weeks

after planting or delaying planting can reduce this effect, as can proper cultivar selection.

Degradable plastic mulches are either photodegradable, breaking down after 30 to 60 days of exposure to sunlight, or biodegradable, broken down by soil microorganisms. Degradable materials do not need to be removed from the field following the growing season, and some may be incorporated into the soil to speed degradation. Reusable materials such as black polypropylene mulch can be used for long- term weed management in nurseries and some high value crops (such as strawberry). Reusable cloth mulch has also been used in lettuce production to promote seed germination and prevent weeds (Finney and Creamer, 2008).

6. Stale Seedbed Preparation: This weed management strategy consists of preparing a fine seedbed, allowing weeds to germinate (relying on rainfall or irrigation for necessary soil moisture), and directly removing weed seedlings via light cultivation or flame weeding. Seeds or transplants can then be planted into the moist weed-free soil. This technique helps to provide an opportunity for crop emergence and growth before the next flush of weeds. If time allows, this can be done twice before planting.

7. Soil Solarization: Solarization consists of heating the soil to kill pest organisms, including fungi, bacteria, and weed seeds. It also reduces populations of various pathogens and nematodes. Soil is covered in summer with clear or black polyethylene plastic and moistened under the plastic, which is left in place for six to seven weeks or longer. Weed seeds and young seedlings are killed by the heat and moisture and through direct contact with the plastic, which causes scorching. Research has demonstrated that solarization from July to October with clear or black plastic provides effective weed control without reducing crop yield (Rieger et al., 2001). Solarization can also be used to produce weed–free soil or potting mix for container production in warm climates (Stapleton et al., 2002), and it has been used in Mediterranean climates to reduce weed competition and increase yields of field-grown cauliflower and fennel (Campiglia et al., 2000).

8. Sanitation and Composting: Many on-farm weed populations exist because of the natural movement of weed seeds and propagules from both neighboring and distant populations by wind, animals, people, and other carriers. Human activity is a major culprit in the introduction of weeds to a farm or to new areas on a farm. Paying close attention to sanitation and seed sources on the farm can help prevent the introduction and movement of weeds:

- Clean farm equipment regularly. If machinery and tools are used in more than one location, they should be thoroughly cleaned before use in adifferent field. Cleaning is especially important when equipment is transferred between farms.
- Limit the amount of off-farm traffic visiting production areas, either by vehicle or foot.
- Apply mulch and compost that is free of weed seeds. Straw mulch, for instance, may contain seeds that will later be a nuisance. To avoid carrying weeds into a field with straw mulch, wet the straw and allow weeds to germinate. Once weed seeds have germinated, dry out the straw bale to kill seedlings by breaking it apart.
- Compost animal manures properly. Animal manures often contain weed seeds, with the source of the manure affecting the number and species of viable weed seeds introduced. To kill weeds and other harmful organisms, compost manures properly before field application. To kill the majority of weed seeds in cattle manure, compost materials at a temperature of at least 180°F (82°C) for no less than three days(Wiese et al., 1998). This temperature is relatively easy to reach in most composting systems.
- Inspect seeds and transplants before planting. Crop seeds, especially grains, may be contaminated with weed seeds.Transplants may have weed seeds in the potting medium if it was not sterilized before use. Buy seeds and transplants from reputable suppliers, and always examine them before planting.

9. Planting Strategies: Date, density, and arrangement for many row and horticultural crops, rapid growth and early canopy closure can result in the suppression of weeds. For this reason, using transplants when possible for horticultural crop production is advantageous. Use of transplants will increase production costs, so the economic benefit of using transplants must be weighed against cost. When it is economically viable, as is the case with many vegetable crops, use of transplants should be considered.

10. Planting Date: The optimal planting date for a crop may vary from year to year depending on weather and soil conditions. Although these factors must be considered when a farmer determines a planting date, planting can be timed to limit competition from potentially troublesome weed populations. In some instances, it is wise to seed or transplant a cash crop early to get canopy closure as soon as possible. Alternatively, some farmers believe that planting on the later side of the window of recommended planting dates makes sense from a weed management perspective. Later planting allows one or two pre-cultivations of weeds, and also can give the cash crop a jump start because of warmer soils.

11. Crop Density: Many researchers have demonstrated that increasing crop density decreases weed competition, though this strategy poses several risks. Lodging and disease may increase in certain crops as crop density increases (Mohler, 1996).

12. Use of manure and compost: Use of organic manure can affect the competition between crops and weeds and in the subsequent crops. Quality of organic manure and method of application affects weed population in crop fields. Broadcasting favours to weed than crops. Similarly improper decomposition of composts promote weeds in fields. Use of legume residues are opposed to chemical nitrogen fertilizer to supplement nitrogen needs of the crop can enhance weed suppression. Legume residues release nitrogen slowly with less stimulation of unwanted weed growth. Applying organic manure near the rows where it is more likely to be captured by the crop will suppress weed growth. Expensive bagged organic fertilizer may be applied in low rates at planting or side dress, relying on mid-season release of nutrients from compost and / or green manures for primary fertility.

13. Water management: Effective water management is key to controlling weeds in crop production. Time and method of irrigation influences weed growth in field. In drip irrigation water is applied in crop root zone and hence weed growth are minimum. There are a number of ways that careful irrigation management can help reduce weed pressure on crops. In rainfed farming water management practices such as mulching, intercropping etc. helps to reduce weed problem.

B. Mechanical Weed Control

Mechanical removal of weeds is both time consuming and labor-intensive but is the most effective method for managing weeds specially in a organic farm. The choice of implementation, timing, and frequency will depend on the structure and form of the crop and the type and number of weeds. Cultivation involves killing emerging weeds or burying freshly shed weed seeds below the depth from which they germinate. It is important to remember that any ecological approach to weed management begins and ends in the soil seed bank. The sol seed bank is the reserve of weed seeds present in the soil. Observing the composition of the seedbank can help a farmer make practical weed management decisions. Burial to 1 cm depth and cutting at the soil surface are the most effective ways to control weed seedlings mechanically.

Mechanical weeders include cultivating tools such as hoes, harrows, tines and brush weeders, cutting tools like mowers and stimmers, and dual-purpose implements like thistle-bars. The choice of implement and the timing and frequency of its use depends on the morphology of the crop and the weeds. Implements such as fixed harrows are more suitable for arable crops, whereas inter-row brush weeders are considered to be more effective for horticultural use. The brush weeder is mainly used for vegetables such as carrots, beetroot, onions, garlic, cerely and leeks. The optimum timing for mechanical weed control is influenced by the competitive ability of the crop and the growth stage of the weeds(Finney and Creamer, 2008).

Flame Cultivation: Broadcast flame cultivation prior to seeding the crop can be used effectively on most organically produced crops. It is more effective on a smooth soil surface than a rough or cloddy surface (Smilie*et al*., 1965). And it is more effective on broadleaf weeds than grasses, but its effectiveness decreases as weeds mature. Grasses and perennial weeds are most tolerant to flaming. Flaming burns grasses and perennial weeds to the soil surface, but sometimes these weeds are capable of regrowth. Seeding or transplanting crops after flame cultivation must be done carefully to prevent soil disturbance that can lead to weed seed germination and establishment.

C. Biological Weed Control

Biological control would appear to be the natural solution for weed control in organic agriculture.

Allelopathy

Allelopathy is the direct or indirect chemical effect of one plant on the germination, growth or development of neighboring plants. It is now commonly regarded as component of biological control. Species of both crops and weeds exhibit this ability. Allelopathic crops include barley, rye, annual ryegrass, buckwheat, oats, sorghum, sudan, sorghum hybrids, alfalfa, wheat, red clover, and sunflower. Vegetables, such as horseradish, carrot and radish, release particularly powerful allelopathic chemicals from their roots.

One approach of utilizing the allelopathic property of crops is to screen genotypes to examine their potential for weed suppression. The strategy for using allelopathy for weed management could be either through directly exploiting natural allelopathic interactions, especially of crop plants, or applying allelochemicals as a source of natural herbicides. However, it is unclear whether the application of natural weed killing chemicals would be acceptable to the organic standard authorities.

Crop Allelopathy and Weed Management

Crops with strong weed-suppressing ability can be used as cover crops, smother, and green manure crops by altering cultural practices and by designing of new cropping systems to aid sustainable weed management. Phytotoxic chemicals can be exuded from all parts of crops, but the roots and leaves are the parts most responsible for their release. Moreover, organisms and insects can produce allelochemicals that could be utilized for sustaining and enhancing agricultural production. Autotoxicity of crops and soil sickness can be described through the presence of phytotoxic exudates from the preceding crops or decomposing crop residues left in the ûelds.

Potential effects of allelopathy: Allelopathic effects can include poor germination, impaired root growth and stunted shoot growth.

Points to be remembered before using allelopathy in weed management programmes

Crop varieties: There can be a great deal of difference in the strength of allelopathic effects between different crop varieties.

Specificity: There is a significant degree of specificity in allelopathic effects. Thus, a crop which is strongly allelopathic against one weed may show little or no effect against another.

Autotoxicity: Allelopathic chemicals may not only suppress the growth of other plant species, they can also suppress the germination or growth of seeds and plants of the same species.

Crop on crop effects: Residues from allelopathic crops, may affect the germination and growth of following crops and weeds. A sufficient gap must be left before the following crop is sown. Larger seeded crops are affected less and transplants are not affected

Soil fertility: Low soil fertility increases the production of allelochemicals. After incorporation of crop/weed residue the allelopathic effect declines fastest in warm wet conditions and slowest in cold wet conditions

Methodology of allelopathy utilization in organic weed management

For better harnessing of allelopathy for reducing weed pressure, growing crops in following manners: (i) alternating between autumn and spring germinating crops, (ii) rotating between annual and perennial crops, (iii) replacing between closed and dense crops.Allelochemicals interactions of plants–plants, plants–soils, plants-microorganisms and plant residues from a crop rotation, play an active role to enhance crop yields. Those allelochemicals released from rotated crops then interacted with many physiological processes, which could help promote the growth and yield of crops. Breeding of new cultivars with strong allelopathic potential may greatly contribute to biological weed control in sustainable agriculture. Some allelopathic crops like sorghum, cucumber, rice, wheat, and soybean have significant allelopathic properties, and suggest that these traits might be genetically correlated.

Beneficial organisms

Little research has been conducted on using predatory parasitic microorgniams or insects to manage weed populations. However, this may prove to be a useful management tool in the future. Natural enemies that have so far been successful include a weevil for the aquatic weed salvinia, a rust for skeleton weed and probably the most famous, a caterpillar (*Cactoblastis* sp.) to control prickly pear. There is also considerable research effort aimed at genetically engineering fungi (myco-herbicides) and bacteria so that they are more effective at controlling specific weeds. Myco-herbicides are a preparation containing pathogenic spores applied as a spray with standard herbicide application equipment.

Use of biocontrol agents for weed control

Some biocontrol agents and commercial mycoherbicides used for weed control are indicated below-

Name of the weed	Bioagent
Parthenism hysterophorus	*Zygrogramma bicolarata*
Lantana camara	*Crocidosema lantana, Teleonnemia scrupulosa*
Opuntia dilleni	*Dactylopiustomentosus, D. Indicus* (cochineal scale insect)
Eichhorneacrassipes	*Neochetina eichhornea, N. Bruchi* (Hyachinth weevil) *Sameodes alliguttalis* (hyancinth moth)
Salvinia molesta	*Crytobagus singularis* (weevil) *Paulinia acuminate* (grass hopper), *Samea mutiplicalis*
Alternanthera philoxaroides	*Agasides hygrophilla* (flea beetle) *Amynothrip sandersoni*

Commercial mycoherbicides

Trade name	Pathogen	Target weed
Devine	*Phyophthora palmivora*	*Morreria odorata* (Strangler vine) in citrus
Collego	*Colletotrichum gleosporoidesf.sp. aeschynomene*	*Aeschynomene virginica* (northen joint vetch) in rice and soyabean
Biopolaris	*Biopolaris sorghicola*	*Sorghum halepense* (Johnson grass)
LUBAO 11	*Colletotrichum gleosporoides* f.sp. *Cuscuttae*	Cuscutta sp. (Dodder)
ABG 5003	*Cercospora rodmanii*	*Eichhorneacrassipes* (water hyancinth)

D. Approved Herbicides

A limited number of natural substances can serve as herbicides on organic farms.

Corn Gluten Meal: The most widely used product in USA is corn gluten meal, a by-product of cornstarch production. Corn gluten meal may be applied as a pre-emergence herbicide (Finney and Creamer, 2008). Time of application is extremely important, as the gluten must be present when weed seeds germinate to inhibit root formation. Weeds affected by corn gluten meal include redroot pigweed, black nightshade *(Solanum nigrum*), common lambsquarters, curly dock, creeping bentgrass*(Agrostis palustris*), purslane, common dandelion *(Taraxacumofficinale*), and smooth crabgrass *(Digitaria ischaemum*). Of weeds that have been tested, barnyard grass *(Echinochloa crus-galli*) and velvetleaf *(Abutilon theophrasti*) are the least susceptible to corn gluten meal (Bingaman and Christians, 1995). Broadleaf species are generally more susceptible than grasses to corn gluten meal. In field studies, weed cover has been reduced up to 84 percent when corn gluten meal was incorporated prior to planting (McDade and Christians, 2000).

Integrated Weed Management (IWM)

IWM is a science-based decision-making process that coordinates the use of macro and micro-environment information, weed biology and ecology, and all available technologies to control weeds by the most economical and ecologically viable methods (Rao and Nagamani, 2010). Integrated Weed Management combines various preventative, cultural, genetic, mechanical, biological, and chemical weed control practices into a single management package. While no single control measure is likely to provide complete weed control, the systematic implementation of the various components of IWM can make significant contributions to weed management efforts. When properly implemented, IWM can lead to sustainable food production, minimized drudgery, and reduce the cost of removing weeds from crops (Chikoye et al., 2004). The decision making process utilized to arrive at the particular weed management technique should be based on cost factor, its impact on the soil and environment. The weather and climate of the farm location should also be put into consideration when formulating a suitable weed management programme. An IWM approach advocates the use of all available weed control options such as selection of a well-adapted crop variety or hybrid with good early season vigor and appropriate disease and pest resistance, that is plant breeding; appropriate planting patterns and optimal plant density; precise timing, strategic placement, and appropriate quantity of nutrient application; appropriate crop rotation, tillage practices, and cover crops; suitable choice of mechanical, biological, and chemical weed control methods; and alternative weed control tools e.g., flaming, steaming, infrared radiation, and sand blasting.

Organic weed management in Crops: Case studies from North Eastern Hill Region of India

As a result of conducive weather conditions and frequent rains, prolific growth of weeds causes serious problems in field crops of the region. The soil is also rich in unhumified organic matters. Weed problem thus assumes an alarming proportion and is a major hindrance in crop production. The high rainfall during April to September and sparse rainfall during winter is a major factor supporting the diverse weed flora. Because of excessive rains during cropping season, it is very difficult to control weeds.

Weed management in rice

Weed infestation is a major challenge to sustain the rice productivity under organic management conditions. Further, intensive tillage practices may also aggravate weed problems in hilly production system. Weeds can reduce rice yield varying from 20 to 80 per cent if not controlled at early stage.

Weed management through cono-weeder in lowland field

Weed control practices includes hand weeding, crop rotation, land leveling, stale seed bed preparation, flooding and use of rotary weeder etc. Longer crop rotation breaks the cycle of weed growth, while proper land preparation, leveling and flooding to uniform depth suppress weeds directly. Use of cono-weeder or rotary weeder in lowland paddy fields is a time saving and cost effective practice. Draining water before operating the cono-weeder is a must to get proper weed control. In upland rice intercropping with legumes like soybean, groundnut etc. (4:2 row ratio) was found to reduce weed problem besides adding to soil fertility.

Application of fresh makrishal (*Schima walchii*) leaves and twigs @ 10 t/ha was found to improve rice yield besides keeping the weeds at minimal level. Regular incorporation of weeds into the soil during fallow period not only reduces the weed problem but also adds to soil nutrient reserve. The longer rotation allows additional time to break weed life cycles and reduce the number of weed seeds in the soil. Other weed-control options center on the use of field flooding to suppress weeds directly and to give the crop a competitive advantage. Flooding will be more effective if fields are precision leveled. Levelling makes the water depth uniform and facilitates rapid flow onto and from the field. Dual cropping of rice with *Azolla* also reduces weed problems and improves productivity through addition of macro and micronutrients. Releasing about 20 ducklings/ha also keeps the weeds at minimal level and increases rice yield. Study conducted at Nagaland showed that two sprays of natural salt NaCl @ 120 kg/ha viz., one after sowing and another at active tillering stage is reduces weed problems and increases the yield of upland paddy (Rathore *et al*., 2012).

Weed management in maize

In *kharif* season weed problem is more due to abundant rainfall. Weeds emerge with the germination of maize seeds and grow along with plants till the early growth period. This causes severe crop-weed competition. Failure of timely weed control gives heavy loss to crop yield. Miaze is a crop grown with wider spacing and hence, mechanical weeding is most congenial. Mechanical weeding should be done 15-20 days after sowing (DAS) of maize, which provide aeration to soil and also manage the weeds. Second weeding can be done after 30-35 DAS and third after 50-55 days sowing. One hand weeding is recommended to remove weeds that are not managed by mechanical weeding. Mulching in between two rows of maize with weed biomass also control the weeds. Mulching with fresh *Eupatorium* 10 t/ha after earthling up at 30 DAS and Soybean green manure incorporation in situ + one HW (45 DAS) has been reported be effective in managing weed in maize under rainfed hill ecosystem of north east India (Das *et al*., 2016).

Weed management in soybean and groundnut

These crops should be kept weed free up to 60 DAS. One mechanical weeding at 20 DAS and two hand weeding at 30 and 50 DAS are sufficient for optimum seed yield. Mulching is also done with weed biomass such as Eupatorium and Ambrosia @ 10 t/ha, which reduced the weed population and also add nutrient to the soil, ultimately improved the crop productivity.

Weed management in lentil and pea in rice fallow

Generally, weed infestation in lentil and pea (in lowland rice–lentil/pea system) is minimum due to puddling and water stagnation in preceding rice crop. However, lentil and pea should be kept free from weeds up to 45-60 days after sowing (DAS) to avoid crop weed competition. Manual or mechanical weeding may be followed to control weeds. Where labour is a constraint, one hoeing or weeding at 30 DAS followed by one hand weeding at 50 DAS check the crop-weed competition.

Conclusions

Effective weed management is the major challenge for successful organic farming. IWM comprising cultural, mechanical and biological practices are warranted for managing weeds in an eco-friendly way in organic farms. In addition to the growing concern for protection of environment, maintain biodiversity and protection of human and animal health, IWM approaches are also good ways of climate change mitigation.Careful selection of cropping systems (intercropping, crop rotation etc) and controlling weeds during critical period of crop-weed competition are important for sustainable weed management. Research efforts are required to develop location specific bio-herbicides for use in organic farms.

References

Agrow, Global Agrochemical Market flat in 2005, Agrow, 490, 2006, 15.

Bingaman, B.R. and N.E. Christians. 1995. Greenhouse screening of corn meal gluten as a natural control product for broadleaf and grass weeds. HortScience. 30 (6): 1256-1259.

Campiglia, E., O. Temperini, R. Mancinelli, and F. Saccardo. 2000. Effects of solarization on the weed control of vegetable crops and on the cauliflower and fennel production in the open field. ActaHorticulturae. 533:249-255.

Chikoye, D., Schluz, L., and Ekeleme, F. 2004. Evaluation of Integrated weed management practices for maize in northern Guinea savanna of Nigeria. Crop Protection, 23: 895-900.

Das, A., Kumar, M., Ramkrushna, G.I., Patel, D.P., Layek J., Naropongla, Panwar A.S., and Ngachan, S.V. 2016. Weed management in maize under rainfed organic farming system, *Indian Journal of Weed Science* 48(2): 168–172, 2016

Finney, D.M. and Creamer, N.G. 2008.Organic Production-Weed Management on Organic Farms.North Carolina A & T State University and the North Carolina Department of Agriculture and Consumer Services. USA.

Kumar B, Kumar R, Kalyani S and Haque M. 2013. Integrated weed management studies on weed flora and yield in *Kharif*maize. *Trends in Biosciences* **6**(2): 161-164.

McDade, M.C. and N.E. Christians. 2000. Corn gluten meal – A natural preemergence herbicide: effect on vegetable seedling survival and weed cover. American Journal of Alternative Agriculture. 15(4):189-191.

Mohler, C.L. 1996. Ecological bases for the cultural control of annual weeds. Journal of Production Agriculture. 9:468-474.

Oerke, E.C. 2005.Crop losses to pests. Journal of Agricultural Science, 144: 31-43.

Ofor, M. O., Ibeawuchi, I.I. and Oparaeke, A.M. 2009. Crop Protection Problems in Production of Maize and Guinea Corn in Northern Guinea Savanna of Nigeria and Control Measures. Nature and science, 7 (11): 45-51.

Ofuoku, A.U., Egho, E.O. and Enujeke, E.C. 2008.Integrated Pest Management (IPM) adoption among farmers in central agro-ecological zone of Delta State, Nigeria. African Journal of Agricultural Research, 3 (12): 852-856.

Oruonye, E. D. &Okrikata, E. 2010.Sustainable use of plant protection products in Nigeria and challenges. Journal of Plant Breeding and Crop Science, 2 (9): 267-272.

Rao, A.N. and Nagamani, N. 2010.Integrated Weed Management in India–Revisited. Indian J. Weed Sci. 42 (3 & 4): 123-135.

Rathore, S.S., Krose, N., Moa, N. Shekhawat, K. and Bhatt, B.P. 2012. Weed management through salt application: an indigenous method from shifting cultivation area, Eastern Himalaya, India. Indian Journal of Traditional Knowledge **11**(2): 254-357.

Rieger, M., G. Krewer, and P. Lewis. 2001. Solarization and chemical alternatives to methyl bromide for preplant soil treatment of strawberries. HortTechnology. 11(2): 258-264.

Smilie, J.L., C.H. Thomas, and L.C. Standifer. 1965. Farm with Flame. Agr. Ext. Pub. 1364:1-16.

Stapleton, J.J., T.S. Prather, S.B. Mallek, T.S. Ruiz, and C.L. Elmore. 2002. High temperature solarization for production of weed-free container soils and potting mixes. HortTechnology. 12(4): 697-700.

Wiese, A.F., J.M. Sweeten, B.W. Bean, C.D. Salisbury, and E.W. Chenault. 1998. High temperature composting of cattle feedlot manure kills weed seed. Applied Engineering in Agriculture. 14(4):377-380.

CHAPTER 4

Pest, Disease Identification and Management in Organic Crop Production

Organic farming is a holistic food production management systems which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity (FAO). It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, wherever possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system. According to International Federation of Organic Agriculture Movement (IFOAM), 'organic agriculture' is a production system that sustains the health of soils, eco-systems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

Nitrogen and pest management are key factors deciding the success of crop under organic farming. In general, pests include weeds, insect-pests, diseases, nematodes, rodents and other organisms causing harm (quantitative or qualitative losses) to our crops. In case of conventional farming systems, farmers or farm managers, in their integrated pest management programme, use the assistance of synthetic chemical pesticides for a quick fix. In contrast, due to ban on the synthetic chemical pesticides, organic farming mostly relies on other non-chemical management practices for controlling or managing these pests.

Identification of diseases and pests

Diagnosis or identification is the process of gathering information about a plant problem and determining the cause. Once the cause has been determined, it is then possible to recommend a solution or remedy. Diagnosing plant problems can involve considerable detective work. Some time there is insufficient information and other time, the primary cause of problems is hidden by more obvious, but less important, problems. Success in diagnosing plant problem depends on how much we know about the host, pathogen, environment and their interaction. Therefore, diagnosis is one of the most important aspects of a plant pathologist's training. Without proper identification of the disease or pests and the diseases causing agents, the control measures can be a waste of time and money and can lead to further plant losses. Many a times, the professionals working in the agricultural research, development and extension are unable to provide a good solution for the crops because of incorrect or misidentification of the plant problems. Symptoms in case of plant diseases and nature of damage and presence of insect-pests are first hand criteria for identification of a particular disease or pest. Some of the important diseases and insect-pests are given crop-wise in following section for easy identification of disease or insect-pests.

1. Wheat (*Triticum aestivum*):

A. Diseases:

1. Black or stem rust of wheat

Key symptoms: Elongated brown urediniopustules mainly on stem and leaf sheath and blades are also affected. In severe attack, plants look unhealthy and fail to form normal ears.

Causal organism (CO): *Puccinia graminis tritici*

Black or stem rust of wheat

2. Brown or leaf rust of wheat


Brown or leaf rust of wheat

Key symptoms: round or circular, brown coloured uredinial pustules appear mainly on leaves which are scattered uniformly all over the leaf surface.

CO: *Puccinia recondita*

3. Yellow or stripe rust of wheat


Yellow or strip rust of wheat

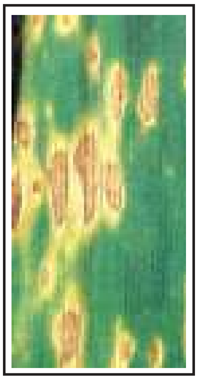
Key symptoms: Smaller bright yellow coloured uredinial pustules appear on leaves in long streaks

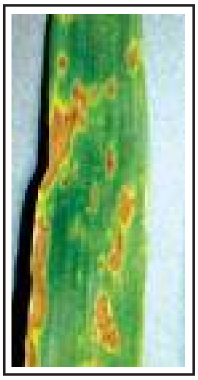
CO: *Puccinia striiformis*

4. Leaf blight of wheat

Key symptoms: Small oval and discoloured lesions appear on leaves and later become irregular and large in size and brown to grey in colour. A bright yellow halo surrounds the spot.

CO: *Bipolaris sorokiniana* and *Alternaria triticina*


Alternaria triticina


Bipolaris sorokiniana

5. Loose smut of wheat

Key symptoms: Every heads of affected plant are converted into a loose, black mass of spores and no grains are formed.

CO: *Ustilago segetum*

Loose smut of wheat

6. Flag smut of wheat

Key symptoms: Leaves twisted, and later withered, mostly culm remain sterile. Formation of grey to greyish black, slightly swollen bands running parallel to veins of older leaves and sheaths. As disease advances, epidermis ruptures and releases black powdery mass of spores.

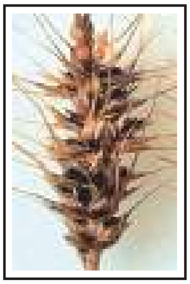
CO: *Urocystis tritici*

Flag smut of wheat

7. Hill bunt or stinking smut of wheat

Key symptoms: Every grains of an ear are replaced with a black oily mass of fungus spores. Rotten fishey smell in the affected field is characteristics to the disease.

CO: *Tilletia tritici*



Hill bunt or stinking smut of wheat

8. Karnal bunt of wheat

Key symptoms: Some grains of ear are bunted due to local infection.

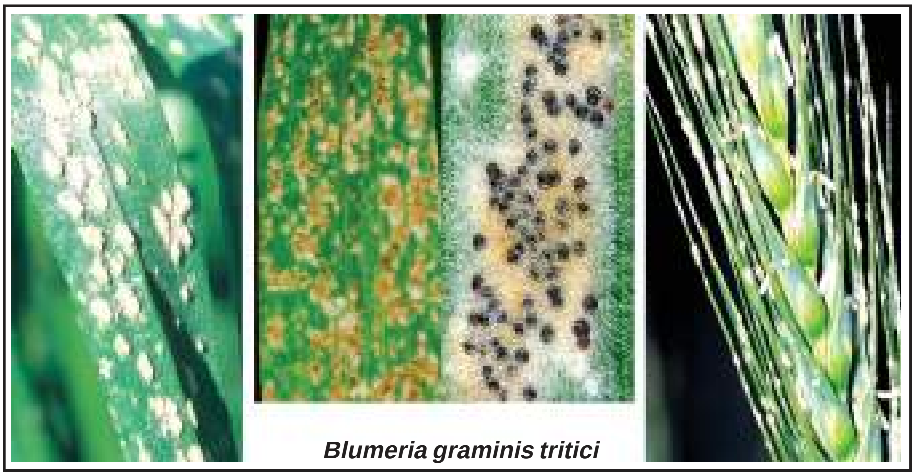
CO: *Tilletia indica*

Karnal bunt of wheat

9. Powdery mildew of wheat

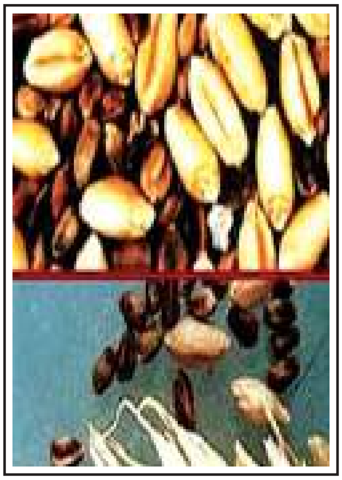
Key symptoms: White powdery flocculent growth of fungus later turns grey or reddish brown as cleistothecia develops.

CO: *Blumeria graminis tritici*



Blumeria graminis tritici

10. Ear cockle or tundu disease of wheat



Ear cockle or tundu disease of wheat

Key symptoms: Affected plants are dwarf and leaves are twisted and wrinkled. Ear heads are small and are also twisted. Grains in the ear are partially or wholly replaces by cockles (galls) which are hard dark brown or black.

CO: *Anguina tritici* (nematode)

11. Molya disease of wheat

Key symptoms: Infected plants are dwarfed and pale in colour like nutritional deficiency. Such symptoms are found in patches and these patches enlarges year by year if not managed properly. Roots damaged and tendency of producing more secondary roots.

CO: *Heterodera avenae* (nematode)

B. Insect pests of wheat:

1. Wheat aphid (*Rhopalosiphum* spp.)

Nature of damage: Adults and nymphs found in abundance in space between leaf sheath, leaf blade and culm and lower leaf surface and also in spaces between spikelets and sucks the plant sap. Their attack may be followed by attack of sooty mould.

2. Pod borer (*Helicoverpa armigera*)

Nature of damage: Larvae feeds on developing grains at dough to near maturity stage. Wheat crop acts as bridge crop for this pest.

2. Rice (*Oryza sativa*):

A. Diseases:

1. Paddy blast

Key symptoms: Spindle shaped spots with brown margin and straw centre which may coalesce to make larger blasted areas on leaves. Necrotic areas on neck region cause neck blast. Infection of junction area of leaf sheath and blade causes collar rot phase.

Causal organism (CO): *Magnaporthe grisea*

Leaf blast Collar rot phase Neck blast phase

2. Brown spot

Key symptoms: Smaller, frog eye shaped spots with dark brown to reddish brown margin and reddish brown to gray centres on mainly on leaves and glumes. Yellow halo surrounds the spot.

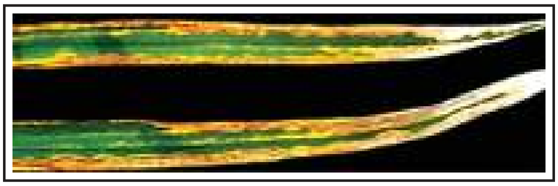
Causal organism (CO): *Bipolaris oryzae*

3. Sheath blight disease

Key symptoms: Lesions develop on sheaths of lower leaves near the water line when plants are in the late tillering or early internode elongation stage. These lesions develop as oval-to-elliptical, green-gray, water-soaked spots about ¼ inch wide and 1/2 to 1 and 1/4 inches long. Lesions expand and its center become bleached with an irregular tan-to-brown border and extends to upper plant parts, including leaf blades, causing extensive, tan, irregularly shaped lesions with brown borders.

Causal organism (CO): *Rhizoctonia solani*

4. Bacterial leaf blight (BLB)



Key symptoms: Lesions begin as water-soaked stripes near the leaf tip or margin and lesion expand inward and downward to cover larger areas. Later they turn yellowish and eventually grayish-white with a wavy margin.

Causal organism (CO): *Xanthomonas oryzae* pv. *oryzae*

5. False smut

Key symptoms: Infected kernels turn into a “smut ball” which initially appear orange but later turnsolive –green to brown outside and yellow to orange inside which may be up to 1/2 inch across.

Causal organism (CO): *Claviceps oryzae*

6. Bakanae or foot rot

Key symptoms: Lesions begin as water-soaked stripes near the leaf tip or margin and lesion expand inward and downward to cover larger areas. Later they turn yellowish and eventually grayish-white with a wavy margin.

Causal organism (CO): *Fusarium moniliforme*

7. Sheath rot disease

Key symptoms: Brown to dark chocolate brown lesions surrounded by diffused light brown halo on boot leaf and top most sheath which covers the panicles. Lesions enlarge and join together to cover most of the sheath. If the sheath is infected before head emergence, the panicles may not emerge. If infection occurs during emergence, the panicle partially emerges.

Causal organism (CO): *Sarocladium oryzae*

8. Stem rot disease

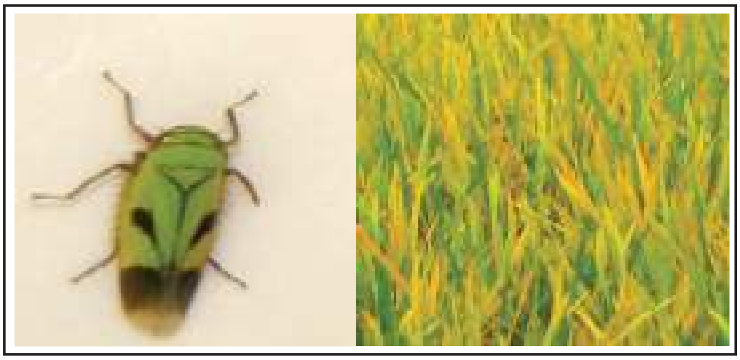
Key symptoms: Rotting of basal portion of hill near soil surface results into death of above culm. White cottony growth can be seen on soil surface surrounding the hills.

Causal organism (CO): *Sclerotium oryzae*

9. Rice tungro disease

Key symptoms: Leaf colour turn yellow to orange from tip to margins with interveinal chlorosis. Stunting of plants with shorter internodes and leaves. Poor panicle with empty grains.

Causal organism (CO): *Rice tungro spherical virus (*RTSV*)* and *Rice tungro bacillifrom virus (*RTBV*)* transmitted by green leaf hopper (*Nephotettix virescens*)



Green leaf hopper Rice tungro disease

10. Rice root knot

Key symptoms: Roots of affected plants shows smaller knots on their tips. Severely affected plants do not response much to fertilizers and remain weak and stunted.

Causal organism (CO): *Meloidogyne graminicola* (nematode)

11. Rice stem nematode or ufra disease

Key symptoms: Tiny white dots on the youngest leaf appear which widen and spread and the leaf collapses. Some emerging leaves and panicles and glumes are twisted and crimpled with empty grains.

Causal organism (CO): *Detylenchus angustus* (nematode)

12. Khaira disease of rice

Key symptoms: Symptoms appear at 2-4 weeks age. Brown spots appear on the older leaves. These spots enlarge and coalesce making the leaf brown. Tillering and growth are reduced and plant remains stunted.

Cause of the disease: Zinc deficiency

B. Insect pests of rice:

1. Yellow stem borer (*Scirpophaga incertulas*)

Nature of damage: Young larvae bore into the central shoot which produces typical 'dead heart' the dead central leaf. At reproductive stage the panicle bearing shoot is cut down from the base of the plants which can be pulled out easily and that is called as 'white head'.

Dead hearts **White heads**

2. Rice gall midge (*Orseolia oryzae*)

Nature of damage: After hatching maggots feed on tip of the leaf sheath and inject a chemical cecidogen which results in the conversion of leaf sheath into a gall which is known as 'silver shoot'.

3. Gindhi bug (*Leptocorisa acuta*)

Nature of damage: The nymphs and the adults suck the sap from the developing milky grains andfrom the base of the panicles. This results into half filled or shrivelled grains.

4. Brown plant hopper –BPH (*Nilaparvata lugens*)

Nature of damage: Nymphs and adults suck the plant sap from the leaf sheath at the base of the plants. Females by way of egg laying cause injury to the leaf sheath. Due to heavy desapping and phytotoxemia, the plants turn yellow and then finally die. This condition is known as 'hopper burn'.

Nymph and adults of BPH

Hooper burn

5. Leaf folder (*Cnaphalocrocis medinalis*)

Nature of damage: The female lays eggs during night hours on the leaves. The young larvae sew the leaf margins from the top and form cone like structures. They remain within the leaf fold and come out during feeding. The larvae feed on chlorophyll which results into the development of white, longitudinal, parallel lines on the leaves, which subsequently dry out.

3. Maize (*Zea mays*):

A. Diseases:

1. Stalk rot of maize

Key symptoms: Infected tissues of stalk first appear soft but later turn into a dry mass of shredded easily disjointed fibres and finally plants topple down.
Causal organism (CO): *Erwinia carotovora*

2. Rust of maize

Key symptoms: Brown coloured, oval to round urediniopustules scattered all over the leaf surface.

Causal organism (CO): *Puccinia sorghi*

3. Leaf blight of maize

Key symptoms: Brown coloured oval to irregular spots initially appear on leaves which later become large patches and may cover larger portion of leaf lamina.

Causal organism (CO): *Cochliobolus sativus* and *Bipolaris victoriae*

4. Downy mildews of maize

Key symptoms: Cottony growth of fungus at lower leaf surface appear initially which later turn into large streaks and patches on leaf lamina.

Causal organism (CO): *Sclerospora rayssiae* and *Sclerospora sorghi*

5. Maize smut

Key symptoms: Grains of cob malformed and contains smut spores. Sometimes male flower organs are also replaced with smut spores.

Causal organism (CO): *Ustilago maydis*

6. Banded leaf and sheath blight of maize

Key symptoms: Leaf sheath, blade and cobs show straw coloured, banded patches of necrotic tissues.

Causal organism (CO): *Rhizoctonia solani*

B. Major insect-pests of Maize crop:

1. Maize stem borer (*Chilo partellus*)

Nature of damage: Central shoot withers and leading to "dead heart". Larvae mines the midrib enter the stem and feeds on the internal tissues. Typical "shot hole" symptom may be found on leaves. Larvae later bore into sob between the rows of grains.

2. Stem fly (*Atherigona orientalis*)

Nature of damage: The maggot feeds on the young growing shoots which results in the formation of "dead hearts**".**

3. Corn worm (*Helicoverpa armigera*)

Nature of damage: Larva feeds on silk and developing milky grains.

4. Chick pea (*Cicer arietinum*)

A. Diseases:

1. Wilt disease

Key symptoms: Branches and leaves of affected plants droop down and finally die at advance stage of disease. Brown discolouration may be seen after tearing the tap root.

Causal organism (CO): *Fusarium oxysporum* f. sp*. ciceris*

2. Collar rot

Key symptoms: Collar region of affected plants girdled and result in death of plants. White growth of fungus can be seen on collar region.
Causal organism (CO): *Sclerotium rolfsii*

3. Ascochyta blight

Key symptoms: Brown coloured circular spots appear on leaves, fruit and elongated spots on stem. Concentric rings are present.
Causal organism (CO): *Ascochyta rabiei*

4. Botrytis grey mold

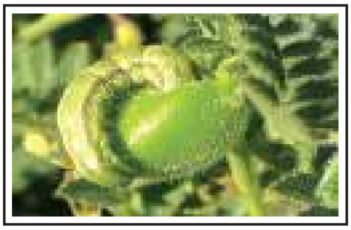
Key symptoms: Diagnostic feature is a grey 'fuzz' which, under high humidity, develops on flowers, pods, stems and on dead leaves and petioles.
Causal organism (CO): *Botrytis cinerea*

5. Sclerotinia stem rot

Key symptoms: Affected branches shows white growth and necrotic areas and die due to girdling and hangs on main plant.
Causal organism (CO): *Sclerotinia sclerotiorum*

B. Insect-pests of chick pea

1. Pod borer (*Helicoverpa armigera*)



Nature of damage: Larva feeds on leaves and developing pods keeping some portion inside and some outside the pods.

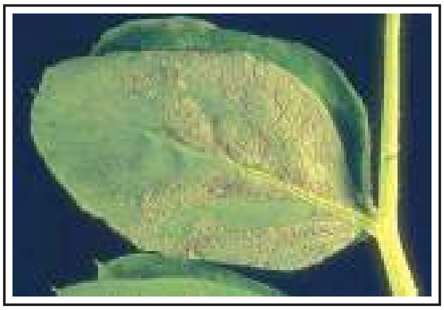
5. Peas (*Pisum sativum*)

A. Diseases:

1. Wilt disease

Key symptoms: Branches and leaves of affected plants droop down and finally die at advance stage of disease. Brown discolouration may be seen after tearing the tap root.
Causal organism (CO): *Fusarium oxysporum* f. sp. *pisi*

2. Downy mildew



Key symptoms: White cottony growth at lower leaf surface and straw coloured spots on upper leaf surface.

Causal organism (CO): *Peronospora viciae*

3. Rust of peas

Key symptoms: Lower surface of leaf covered initially with whitish lemon coloured pustules and later with dark rust coloured pustules.

Causal organism (CO): *Uromyces fabae*

4. Powdery mildew of peas

Key symptoms: All plant parts are covered with white powdery mass of fungal growth giving a powdery appearance.

Causal organism (CO): *Erysiphe polygoni*

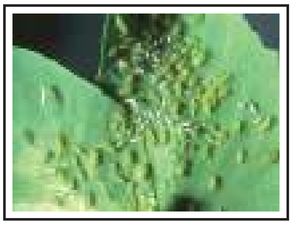
B. Insect-pests of peas:

1. Pea stem fly (*Ophiomya phaseoli*)

Nature of damage: The maggots bore inside the stem leading to wilting of the plants.

2. Pod borer (*Helicoverpa armigera*)

Nature of damage: Larva feeds on pods keeping some portion inside and some outside the pods.



3. Pea aphid (*Acyrthosiphon pisum*)

Nature of damage: Adult and nymphs suck the sap from leaves and pods giving plants stunting appearance.

6. Pigeon peas (*Cajanus cajan*)

A. Diseases:

1. Wilt disease

Key symptoms: The infected plants become yellow in colour followed by dropping and finally the wholeplant dries up. The disease can be confirmed by browning of the xylem vessels after tearing at basal portion of stem.

Causal organism (CO): *Fusarium udum*

2. Phytophthora blight

Key symptoms: The seedlings are more prone to disease and show crown rot symptoms, topple over and dry. In older seedlings the symptoms appear as water soaked lesions and later may become necrotic. Diseased plants can be spotted easily at 40 DAS. Symptoms of stem blight as well as leaf blight are often observed on infected pigeon pea crop during favourable environmental conditions.

Causal organism (CO): *Phytophthora drechsleri*

3. Sterility mosaic of pigeon pea

Key symptoms: Patches of bushy pale and green plants with smaller leaves, without flowers or pods.

Causal organism (CO): Pigeon pea sterlity mosaic virus (PSMV) transmitted by mites (*Aceria cajani*)

B. Insect-pests of pigeon peas:

1. Pod borer (*Helicoverpa armigera*)

Nature of damage: Larva feeds on pods keeping some portion inside and some outside the pods.

2. Spotted Pod borer (*Maruca testulalis*)

Nature of damage: More attack on early maturing varieties. Larvae cause extensive damage to floral buds and flowers. The characterestic symptom is webbing together of flowers, pods, and leaves with frass often on pods and shoot tips.

3. Pod fly (*Melanogromyza obtusa*)

Nature of damage: The small black coloured fly lays eggs through the wall of the developing pod and the white legless larva, 3 mm long, feeds inside the green seed. Generally only one maggot develops in one seed. The brown puparium is formed inside the pod but outside the seed. The maggot pupates inside the pod after making a small hole on the pod covering it with a thin membranous stricture.

4. Leaf webber (*Grapholita critica*)

Nature of damage: The creamy-yellow larva often found binding leaves together and feeds on the chlorophyll while remaining inside the web. Leaflets are webbed together with silk and the larva feeds within the web. As the web often includes the terminal bud, further growth of that shoot is prevented.

7. Other pulses

Urd and moong beans

A. Diseases:

1. Yellow mosaic

Key symptoms: The infected plants become yellow in colour followed by dropping and finally the whole plant dries up. The disease can be confirmed by browning of the xylem vessels after tearing at basal portion of stem.

Causal organism (CO): *Mung bean yellow mosaic geminivirus* transmitted by whitefly

Yellow mosaic on leaves

White flies

2. Cercospora leaf spot

Key symptoms: Leaf spots with brown to greyish centre and reddish brown border are its characteristic symptoms.

Causal organism (CO):
Cercospora canesens

3. Anthracnose

Key symptoms: The characteristic symptoms are circular brown sunken spots with dark centres and bright red orange margins on leaves and pods. This disease affects all aerial plant parts, however, the leaves and pods are more vulnerable.

Causal organism (CO): *Colletotrichum* spp.

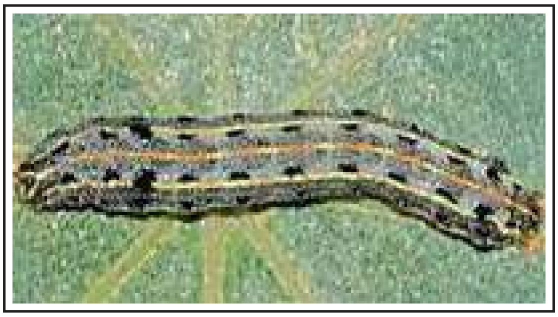
B. Insect-pests of moong and urd bean

1. Bihar hairy caterpillar (*Spliosoma obliqua*) and red hairy caterpillar (*Amsacta moorei*)

Nature of damage: The young caterpillars start feeding on leaves in a gregarious form. They eat away all the green matter of the leaves and it can be easily recognized by perforated, dusty white coloured leaves in the field.

Bihar hairy caterpillar

2. Tobacco caterpillar (*Spodoptera litura*)



Nature of damage: The young caterpillars start feeding right from cotyledonary leaves in a gregarious form. They eat away all the green matter of the leaves.

8. Oil seeds diseases and pests

I. Rapeseed and Mustard

A. Diseases:

1. White rust

Key symptoms: White blisters appear on lower surface of leaves which may enlarge and cover entire leaf and leaf dry. Infection of terminal buds produces characteristic staghead symptoms.

Causal organism (CO): *Albugo candida*

2. Alternaria leaf spot

Key symptoms: Dark colour, circular spots appear on the leaves with characteristic concentric rings. Spot may enlarge and cover entire leaf and leaf may die. Siliqua also show leaf spot.
Causal organism (CO): *Alternaria brassicae* and *A. brassicicola*

3. Sclerotinia stem rot

Key symptoms: Water soaked lesion develop mainly on basal portion of stem which later enlarge and kill the above portion of stem. White cottony growth of the fungus can be observed on affected parts.
Causal organism (CO): *Sclerotinia sclerotiorum*

B. Insect-pests of Mustard

1. Mustard aphid (*Lipaphis erysimi*)

Nature of damage: The wingless nymph and adults suck the sap from growing portion of twigs and may cover most of the portion of stem. Plant growth and flowering-fruiting stopped.

2. Mustard saw fly (*Athalia lugens proxima*)

Nature of damage: Larva initially nibbles leaves, later it feeds from the margins towards the midrib and consume entire leaf. The grubs cause numerous shot holes and even riddled the entire leaves by voracious feeding.

3. Mustard painted bug (*Bargrada hilaris cruciferarum*)

Nature of damage: Insect are seen in gregarious form on plants. Young plants wilt and wither as a result of the attack. Adult bugs excrete resinous substances which spoils the pods.

Integrated Pest Management in Organic Farming

The ecological approach which encourage and enhance biological cycles within the farming system; increase biodiversity of flora harbouring natural enemies (predators, parasitesand parasitoides); enhance internal resistance of crop plants to pests; making soil suppressive to soil borne pests and diseases, is base for pest management in organic situation. Many a times, due to unavailability of a control measure, farmer has to tolerate the losses in yield due to pests in organic farming conditions. In organic farming in India, farmers can only use the pesticides listed in National Standards for Organic Production (NPOP) updated time to time. In absence of synthetic chemical pesticides, cultural, host resistance, physical, biological, botanical, bio-rational methods etc. are mainly employed for pest control in organic farming with uncertainty in the level of pest control.

Maintenance of Agro-biodiversity at Farm

Maintenance of an appropriate habitat for sustaining different life forms is an essential part of Organic Farming. This agro-biodiversity can be created by ensuring crop diversity, plantation of wide varieties of trees and shrubs fit to the local climatic conditions. These plants/trees apart from increasing the soil health, also attracts birds, pollinators and many natural enemies of the insect-pests of crops by providing them shelter and food (nectar etc.) source. These birds and natural enemies (predators, parasites or parasitoides) in turn, regulate the pest population in agro-ecosystems. Pollinators attracted, also helps in increasing the crop yield by facilitating pollination particularly in cross pollinated crops. The boundary plantation of these shrub/tree species may be adopted in a multistoried fashion. For example, for a 10 acre organic farm, five-six neem trees (*Azadirachta indica*), one to two tamarind (*Tamarindus indica*), two gular (*Ficus glomerata*), eight to ten ber (*Ziziphus mauritiana*), one to two aonla (*Emblica officinalis*), one to two drum stick (*Moringaoleifera*) and 10-15 bushes of other wild species fit to the locality should be planted in plain region of the country (Yadav, 2011). The subabool (*Leucaena leucocephala*) can be a good source for forage and green leguminous nitrogen rich leaves for good quality compost or as soil mulch. Lemon can also be included for attracting pollinators and natural enemies. This also provides additional yield of fruits. Many of the above tree species provide fruits and thus additional income to the farmer. Neem which has a wide-spectrum pest control activity, provides leaves and seed kernels for preparation of neem leaf of neem seed kernel extracts which are used for managing a wide variety of insect-pests and vectors of virus diseases.

In between *Glyricidial Sesbania* rows, few plants of pesticidal value such as *Adhathoda vasica*, *Vitex negundo, Calotropis procera* or *C. gigantia, Datura* spp., *Ipomoea carnea* (Besharam) etc. should be planted for making preparations for pest/disease control. Some of these plants also serves as medicinal plants for farm livestocks for organic cure of diseases. Surrounding the farm of garden, there should be hedgerows or a live fence of coppiced or pollarded, multipurpose, deep-rooted trees and shrubs and medicinal herbs such as *Adathoda vasica, Vitex negundo, Jatropha curcas* etc, for maintaining ecological diversity which is an essential component of any successful organic farming system. The *Calotropis* spp. attract early infestation of aphids in north plains and hence, facilitate the early establishment of predatory insects like lacewing and ladybird beetle which further moves to and controls the aphids on main crop.

Tillage, land configuration and crop spacing

Tillage is old age practice of pest management in agriculture. Deep summer ploughing exposes the roots of many weeds and facilitate their drying. It also helps in exposing the hibernating stages of insects for predation or killing by desiccation. The sclerotia and other resting structures of many pathogenic fungi and stages of nematodes get destroyed by summer ploughing. Intercultural operations besides proving proper aerations and growing conditions to soil, also helps in weed management. Hence summer ploughing and proper interculture should be among main strategies for weed, pest and disease management in organic farming.

Planting of crops especially turmeric, ginger, pulses, vegetables, maize etc. on raised beds or bunds particularly during rainy season provides protection against some soil borne diseases caused by *Pythium* and *Phytophthora* spp.

Crop spacing should be kept at larger side to avoid the build-up of congenial environment for pests and diseases attack. Widely spaced crops have proper aeration and lower humidity and lesser attraction for insect shelter and thus avoid the heavy attack of pests and diseases. Keeping 2’ space vacant at every 3-4 meters in case of basmati or non-basmati rice helps in managing brown plant hopper, sheath blight disease and other pests. Larger plant to plant distance in case of okra helps in minimizing yellow vein mosaic disease due to lesser white fly vectors.

Soil solarisation and pest management

Soil solarisation is a technique of raising the soil temperature by clear plastic sheets which allows shorter wavelength solar radiation to enter into soil and heat it up and at the same time it restricts the longer wavelength radiation into soil during night time. Thus, the soil solarization keeps soil temperature continuously above lethal range (up to 60^0C) to many soil borne plant pathogensof mesophilic nature (*Fusarium* spp*.* *Verticillium* spp*.* etc*.*), nematodes (root knot nematode), weeds (annual grassy weeds and some broad leaved weeds also), and hibernation stages of insect-pests. Solarization of soil also creates a microbial vacuum which is later covered at faster rates by competitive microflora and thus helps in reducing soil pathogen population. It also promotes crop growth by modifying soil environment through nutrient solubilizing and cycling. This practice is done during summer months (May-June) to exploit maximum benefit of solar heating. Two months solarization is sufficient to provide its benefit for about three consecutive crop seasons. The thickness of clear polyethylene sheets should be in the range of 25-30µm. The soil before solarization should be well prepared and has proper moisture for maximum conductivity of heat into the soil. This is a best practice for controlling weeds; root knot nematode and root rot and wilt diseases in nursery as well as high value crops. The sowing of seeds or transplanting of nursery after soil solarization should be done without much disturbance to the soil. Soil application of biological agents just after opening of polyethylene sheets at completion of solarization gives maximum benefit of bioagents in controlling diseases and promoting plant growth.

Conversion of soil to organic and suppressive to pests and diseases

The soil of an organic farm should be converted into a pure organic by the application of low input alternatives like mixture of compost and vermicompost in 2:1 ratio @ 2.5tons/ acre and it should also be enriched with biofertilizer cultures i.e. *Azotobacter* (4kg) and phosphate solubilising bacteria (PSB) @4kg or consortia of microbes at final land preparation. Mandatory planting of legumes with crops helps in maintaining the soil fertility. **Jivamrut** is a low input alternative applied @200 lit per acre. Soils poor in phosphorus are added with low grade mineral rock phosphate @300kg/acre. Repeated application of Jivamrut can be done at irrigation after the germination. After harvesting of legumes (picking of pods or separation of grains), recycle the total remaining biomass into the field. Also recycle entire residue of other crops either as such or after composting.

Apply preparations of *Trichoderma* and *Pseudomonas fluorescens/ Bacillus subtilis* @5kg/ha along with organic manure during final stage of soil preparation which could suppress many soil or seed borne diseases of many crops including nematodes. Soil application of *Beauveria bassiana* or *Metarhizium anisopliae* @2.5kg/ha has been found effective for controlling many important insect-pests including foliar insects, termites and white grubs. Application of crushed oil cakes @500kg, 100kg of neem cake along with organic manures and biodynamic preparations, has been reported to enhance the population of competitive microorganisms in the soil and also increase the its suppressiveness to soil borne plant pathogens.

Multiple cropping and mixed cropping

Mixed cropping is the outstanding feature of organic farming in which variety of crops are grown simultaneously or at different time on the same land. In every season, care should be taken to maintain legume crops by at least 40%. Mix cropping promotes photosynthesis and avoids the competition for nutrients, because different plants draw their nutrients from different depth of soil. The legume fixes atmospheric nitrogen and make available for companion or succeeding crops. Deep rooted plants draw nutrients from deeper layer of soil and bring them to the surface of soil through their leaf fall. So the nutrients leached down to lower strata are further brought back to upper layer by these deep rooted plants. Also help in protecting soil from soil erosion. Farmers should select the crops combination according to their needs and season. In addition to the above,mixed cropping is also a strategy to compensate the losses caused by pests and diseases. If main crop is damaged by the disease or pests, the mixed crop can compensate for the losses in main crop. Some of the mixed crops i.e. cow pea or *Dhaincha* smother weeds in between the rows of wide spaced crops and also add nitrogen to the soil. Any other interested crop which is having weed smothering property and if, compatible with main crop, can be planted in rows of main crop. Intercropping of Marigold in between wide spaced crops can smoother the weeds and also controls many nematode species of the crops.

Entire organic farm should have at least 8-10 types of crops at every time. Each field/ plot should have at least 2-4types of crops out of which one should be legume. In case if only one crop is taken in one plot then adjacent plot then adjacent plots should have different crops. For maintenance of diversity and pest control, randomly plant 50-150/ acre vegetable seedlings for home consumption and 100 plants/ acre of marigold inside all the crops. Even exhaustive crops such as sugarcane can also be grown with suitable combination of various legume and vegetable crops with optimum productivity. Crop combinations with synergistic effects should be taken for inter/mixed croppinge.g. maize with beans and cucumber, tomatoes with beans and cucumber, tomatoes and sugarcane with onions and marigold.

Crop rotation

Crop rotation is the back bone of organic farming. It is practice of growing a series of dissimilar or different types of crops on a piece of land in a definite time schedule. To keep the soil healthy and to allow the natural microbial systems working, crop rotation is must. Generally 3-4 years of crop rotation is followed. All high nutrient demanding crops should precede and follow low nutrient requiring crops like legume dominated crop combinations. Rotation of a host crop with non-host crops for a particular pest helps in controlling soil borne diseases and pest. It also helps in improving soil structure through different types of root system (deep rooted vs. shallow rooted crops). Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also find place in planning rotations to maintain soil fertility and productivity. Breaking the life cycle and population build-up of pests, pathogens and weeds in agro-ecosystems, crop rotation is one of the main strategies. During adoption of crop rotation, care should be taken to include non-host crops of a particular pest or pathogen, to manage that particular pest. The important benefits of crop rotations are:

a. It exploits the differential in nutrient requirement of different crops categories and thus improves the soil fertility

b. It improves soil structure through different types of root systems, and

c. It helps in breaking the life cycle and population build-up of pests, pathogens and weeds in agro-ecosystems

Use of resistant varieties

Since,the synthetic chemical pesticides are strictly prohibited in organic crop production and there are not many options under biological, botanical or other strategies of pest management allowed, the use of pest/disease resistant or tolerant and weed smothering varieties must be in our package of practices to manage the pests. The varieties of crops resistant or tolerant to pests vary from region to region; hence they should be selected according to locality. If no resistant or tolerant varieties are available, intensive use of biological or botanical pesticides along with cultural management should be done to manage the pests or disease.

Induced resistance is another area which can be exploited in organic farming. Seed treatment with bioagents like *Trichoderma* and *Pseudomonas fluorescens/ Bacillus subtilis* has been reported to induce broad range resistance in many crops against various pathogens.

Treatment of seed/ planting material

Prevention of pest or pathogen is best strategy particularly in organic cultivation of crops where we do not have much effective options of control beyond threshold level of disease or pest attack. As for as possible, the seed or planting materials should be free from the disease causing pathogens, pests and weed seeds. Some of the formulations and seed treatment methodologies which have been reported effective under organic farming are listed as below:

1. Hot water treatment

Hot water treatment is often used to eradicate the inoculum of plant pathogens and hibernating stages of insect-pests from seed, bulbs, setts and nursery stocks. Treatment of seeds at 52-54^{0}C temperature for 25-30 minutes eliminates most of the pathogens (including fungal, bacterial, phytoplasmal and viral pathogens) and pests from the seed. At this temperature, the viability of seed is not affected much. In case of organic farming where we do not have options of broad spectrum fungicides, antibiotics or systemic insecticides, hot water treatment can play a great role for eliminating seed borne inoculum. In case of paddy hot water treatment of seeds at 54^{0}C for about 25-30 minutes can eliminate many of the seed borne pathogens including *Bipolaris oryzae*, *Xanthomonas campestris* pv. *oryzae*. Extreme care should be taken during hot water treatment of the seeds, because a slight rise in temperature than the recommended can negatively affect the seed germination and the lower temperature could not effectively eliminate the inoculum from the seed.

2. Seed treatment with biocontrol agents

Treatment of seed or planting materials with fungal or bacterial bioagents like *Trichoderma viride* or *T. harzianum* (@4g/ kg seed) or *Pseudomonas fluorescens* (10g/kg seed) or consortia of different bioagents can suppress many of the seed and soil borne plant pathogens and nematodes. Seed treatment is also a good delivery system of bioagents into the rhizosphere. Besides suppressing plant diseases, these bioagents have also been reported to promote the plant growth and thus early establishment of the seedlings. Treatment of seed with these bioagents and keeping them for overnight at suitable temperature and humidity to activate the bioagents, before sowing, is known as **seed bio-priming**. It is the best method of seed treatment and helps in early establishment of bioagent into the applied niche. For seed bio-priming, seed treatment should be done in evening and incubate the treated seeds in shade for overnightand perform sowing in next morning.

3. Seed treatment with Beejamrut

Bijamrut is a biodynamic preparation commercially exploited foe seed treatment in organic farming and reported to suppress many seed borne diseases. For preparation of Bijamrut, put 5 kg fresh cow dung in a cloth bag and suspend in a container filled with water to extract the soluble ingredients of dung. Suspend 50g lime in one litre of water separately. After 12-16 hours, squeeze the bag to extract all the ingredients of cow dung and add 5 litre of cow urine, 50g of virgin forest soil, prepared lime water and 20 litre water. Again incubate the preparation for 8-12 hours. Filter the content and this filtrate is ready for seed the treatment. Apply he amount of Bijamrut on seed which can make a layer over it and dry it in shade before sowing.

4. Other seed treatment formulas

Seed treatment can also be done with *Panchgavya* extract, Turmeric rhizome powder+cow urine, *Dashparni* extract etc. Treatment of seeds with symbiotic nitrogen fixing bacteria e.g. *Rhizobium* spp. (in legume crops) or non-symbiotic nitrogen fixing bacteria e.g. *Azotobacter*, *Azospirillum* etc. in case of other crops must be done to fix the atmospheric nitrogen in the soil. Many of the *Pseudomonas fluorescens* strains have been reported to solubilise the fixed phosphorus of the soil and make them available to crops. Seed treatment with these **phosphate solubilising** microorganism should be a mandatory practice in organic farming.

Mechanical methods

Removal of affected plants and plant parts, collection and destruction of egg masses and larvae, installation of bird perches, light traps, sticky coloured traps and pheromone traps are most effective mechanical methods of pest control. In bigger plots of crop, put ‘T’ type of bird perches with 5-6 feet height which attracts the birds to sit over and predate the insect larvae and adults infesting the crop. The boundary trees and shrubs planted in farm also serve the purpose of bird perches.

Light traps are very effective for collecting and destroying adults of white grub, many of the moths and borers and termites. **Pheromone traps** of methyl-euginol are very effective for collecting and destroying the adult stages of fruit fly in orchards (guava, mango etc.) and cucurbitaceous vegetables.

Weed management and removal of alternate and alternative hosts

Weed management is one of the biggest problems in organic farming. Besides direct reduction in crop yield and quality, weeds harbour a variety of plant pathogens and insect-pests particularly during off season, which are transferred to crops by vectors and other means during crop season and thus causing indirect direct losses also. Due to ban on chemical herbicides, weed management mainly relies on cultural, manual, mechanical and other means in case of organic farming. Use of seeds and planting materials free from weed seeds is a preventive measure. Certain weeds like *Trianthema portulacastrum, Amaranthus viridis* etc. mainly spread through organic manure and care should be taken to decompose weeds only before fruiting stage during compost preparation. The farm animals should also be fed weeds grasses before fruiting stage only. **Stale seed bed** (pre-sowing irrigation of field and allowing weed seeds to germinate and then destroy them during preparatory tillage) technique can be used to reduce weed seed bank in soil. Manual weeding and mechanical interculture through various hoes and instruments remain main options for weed management in organic farming. As for as possible keep organic field free from weeds which hosts insects and pathogens of crop plants (removal of alternate hosts).

Balance crop nutrition for pest and disease management

Properly balanced nutrition is a critical factor in allowing crops to realize their full yield potential. The application of manuresand fertilizers to accomplish this balance is a universal practice in commercial crop production. Macro and microelements have long been recognized as being associated with size, quality, and yield of crops, and also affect the attack of weeds, pests and diseases. Pathogens, as well as crops, have nutritional requirements of their own. Two major objectives of nutrient applications to crops for protection from pathogens can be summarized as follows;

1. Avoid plant stress, which may allow crops to better withstand pathogen attack,
2. Manipulate nutrients to the advantage of plants and disadvantage of the pathogen

Since organic crop production exclusively depends on organic manures which provide sufficient quantities of major and micronutrients to crop plant and thus plant health is maintained and it can better withstand the attack of pests and diseases. Generally organically grown crops are less affected by pest and diseases.

Pest and disease management in standing crop

As in organic farming management use of synthetic chemicals are strictly prohibited, the pest management is achieved by (i) cultural or agronomic measures, (ii) mechanical methods, (iii) biological or by (iv) organically acceptable botanical extract or some chemicals such as copper sulphate and soft soap etc. The list of permitted, restricted and prohibited inputs for pest control is given in **Chapter 9, Pages 574-577**. Mechanical and cultural alternatives described in details in previous sections. The use of bioagents and herbal preparations as bio-pesticides are described as below:

Biological alternative

Mass release of predators, parasites and/or parasitoides

Use of pest predators, parasites or parasitoides has also proved to be effective method of keeping pest problem below ETL. Inundative release of egg parasitoides *Trichogramma* spp. @50,000 to 1,00,000 parasitized eggs per hectare, *Chelonus blackburni* @15,000 to 20,000 per hectare, pupal parasitoides *Apentalis* sp.@ 15,000 to 20,000 per ha and predator *Chrysoperla carnea* @ 5,000 per ha., after 15 days and others parasites and predators after 30 days of sowing, can also effectively control pest problem in organic farming. Four to five releases of egg parasitoides *Trichogramma* spp. in rice and sugarcane gives almost total control of borers which are major pests of these crops.

Use of Bio-pesticides

For the management of fungal diseases and nematodes the *Trichoderma viride* or *T. harazianum* are found to be best. Four to five kg of formulation with desired number of viable spores is sufficient for one hectare. They can be applied as spray at regular intervals fro desired level of disease control. *Pseudomonas fluorescence* formulations @ 4g/kg seed either alone or in combination with *Trichoderma* spp. mange most of the seed and soil borne diseases. It can also be used as spray for managing the crop diseases.

For controlling the insect-pests, formulations *viz*. *Beauveria bassiana*, *Metarhizium anisopliae*, *Nomuraea rileyi*, *Verticillium* sp., are available in the market and can manage their specific insect-pest. Massive application of *Beauveria bassiana* can be done to manage many insect-pests including beetles, caterpillars, termites etc. inorganically grown field or orchard crops. Formulations of bacterial bioagents *Bacillus thuringiensis* @ 0.5-1.0 kg/ha are effective against Lepidoptera and Coleopterans as well as some other insect species. Viral biopesticides of *Baculovirus* group vi. Granulosis viruses (GV) and nuclear polyhedrosis viruses (NPV) provided a great scope in plant protection field. Spray of nuclear polyhedrosisviruses(NPV) of *Helicoverpa armigera* (Ha-NPV) or *Spodoptera litura* (Sl-NPV) @ 250 larval equivalents are very effective tools to manage the *Helicoverpa* sp. or *Spodoptera* sp. respectively which are wide host range insect-pest in many crops (particularly pulses and vegetables).

Use of botanical pesticides

Many plants are known to have pesticidal properties and the extract of such plants or its refined forms can be used in the management of pests. Among various plants identified for the purpose, neem has been found to be most effective.

Neem (*Azadirachta indica*) preparations

Neem has been reported to be effective in the management of approximately 200 insects, pests and nematodes. Neem is very effective against grasshoppers, leaf hoppers, plant hoppers, aphids, jassids, and moth caterpillars.It has strong repellent and anti-feedant activities. Neem extracts, are also very effective against beetle larvae, butterfly, moth and caterpillars such as Mexican bean beetle, Colorado potato beetle and diamond black moth. Neem is very effective against grasshoppers, leaf minor and leaf hoppers such as variegated grasshoppers, green rice leaf hopper and cotton jassids. Neem is fairly good in managing beetles, aphids and white flies, mealy bug, scale insects, adult bugs, fruit maggots and spider mites.

Neem Seed Kernel Extract (NSKE)

For preparation of neem seed kernel extract 5kg of neem seed is grinded gently to make a fine powder of it. Soak the ground kernels in 10 litres of water for overnight. In morning stir the suspension till it becomes milky white. Filter the suspension through double layer muslin cloth and make up the volume to 100 litre by adding fresh water. Add 1% soft soap and mix the spray suspension thoroughly. Care should be taken to use good quality neem seed kernels (not more than eight months old). Always use freshly prepared NSKE for pest control. Spray NSKE in late afternoon to get best results. NSKE prepared from 8-12 kg neem seed is sufficient for one hectare crop.

Some other pest control formulations

Many of the organic farmers and NGOs have developed large number of innovative formulations which are effective in managing various pest and diseases of crop. Although none of these formulations have been subjected to scientific validation but their wide acceptance by farmers is witness of their usefulness. Farmers can try these formulations, as they can be prepared on their own farm without the need of any purchases. Some of the popular formulations are detailed as below:

Chilli- Garlic extract: Crush 1kg *Ipomoea carnea* (*besharam*) leaves, 500 g hot chilli, 500 g garlic and 5 kg neem leaves in 10 lit cow urine. Boil the suspension 5 times till it becomes half. Filter and squeeze the extract. Store the preparation in glass or plastic bottles. Two to three litres of this extract diluted to 100 lit of water and used for one acre area. This is widely used preparation and useful against leaf roller, stem/ fruit/pod borer.

Cow urine: Cow urine diluted with water in ratio of 1:20 and used as foliar spray is not only effective in the management of crop disease and insects, butalso acts as effective growth promoter for the crop.

Fermented Curd water: In some parts of central India, fermented curd water (butter milk or *Chhaachh* or *mattha*) is also being used for the management of white fly, jassids, aphids etc.

Dashparni Extract: Crushed neem leaves 5 kg + *Tinospora cordifolia* (*giloya*) leaves 2 kg, *Annona squamosa* (custard apple) leaves 2 kg, *Nerium indicum* leaves 2 kg, *Pongamia pinnata* (Karanja) leaves 2 kg. Green chilli paste 2 kg, garlic paste 250 gm, cow dung 3 kg, *Calotropis procera* leaves 2 kg and cow urine 5 litre in 200 litre water and fermented for one month. The suspension is shaken regularly three times a day. Extract is finally obtained after crushing and filtering. The extract can be stored up to 6 months and used to control insect-pests and diseases of crops @500 litre/ha.

Neem-Cow urine Extract: Crush 5 kg of neem leaves in water. Add 5 lit cow urine and 2 kg cow dung, ferment for 24 hrs with intermittent stirring. Filter, squeeze the extract and dilute to 100 lit. Use this extract as foliar spray over one acre. This is useful against sucking pests and mealy bugs.

Mixed leaves extract: Crush 3 kg neem leaves in 10 litres of cow urine. Crush 2 kg custard apple leaf, 2 kg papaya leaf, 2 kg pomegranate leaves, 2 kg guava leaves in water. Mix both the formulas and boil 5 times at some interval till it becomes half. Incubate for 24 hrs, then filter and squeeze the extract. This formula can be stored in bottles for 6 months. Dilute 2-2.5 litre of this extract in 100 litre of water for 1 acre of crop area. This is useful against sucking pest, pod/ fruit borers.

Broad spectrum formulation

Mix 3 kg fresh crushed neem leaves and 1 kg neem seed kernel powder with 10 lit of cow urine in a copper container. Seal the container and allow the suspension to ferment for 10 days. After 10 days, boil the suspension, till the volume is reduced to half. Grind 500 g green chillies in one lit of water and keep for overnight. In another container crush 250g of garlic in water and keep for overnight. Next day mix all the ingredients to make broad spectrum pesticide. This preparation can be used on all crops against wide variety of insects. Dilute 250 ml of this preparation in 15 lit of water and use it for spray. About 400-500 litre diluted suspension is required for one hectare of crops.

Conclusion

Pest and diseases still remains major constraints in organic crop production and their proper management decides the success of crop under organic situation. The ecological based approaches which encourage and enhance biological cycles within the farming system; increased biodiversity of flora harbouring natural enemies (predators, parasites and parasitoides); enhanced internal resistance of crop plants to pests; making soil suppressive to soil borne pests and diseases, is base for pest management in organic situation. In organic crop production in India, farmers can only use the pesticides listed in National Standards for Organic Production (NPOP) updated time to time by the concerned ministry. In absence of synthetic chemical pesticides, cultural management, host resistance, physical, biological, botanical, bio-rational methods and some indigenous preparations are mainly employed for pest control in organic crop production.

References

Agrios, G.N. (2005). Plant Pathology. Elsevier Academic Press, London, U.K.

Linker,H. M. D. B.; Orr, D.B.and Barbercheck, M. E. (2014) Insect Management on OrganicFarms. North Carolina Cooperative Extension Service. 36p.

NPOP (2014). National Programme for Organic Farming, Ministry of Commerce, New Delhi.

Rechcigl, N.A. and Rechcigl, J.E. (1997). Environmentally Safe Approaches to Crop Disease Control. Lewis Publishers, New York.386p.

Singh, R.S. (2005). Plant Diseases. 8th Ed., Oxford and IBH Pub. Co. Pvt. Ltd., New Delhi. 720p.

Vennila, S.; Birah, A.; Kanwar, B. and Chattopadhyay, C. (2016). Success stories of Integrated Pest Management in India. ICAR- National Research Centre for Integrated Pest Management, New Delhi- 110 012.

Yadav, A. K. (2011). Organic management an integrated approach. *In*: Recent Developments in organic Farming (Eds. J.M.L.Gulati and T. Barik). OUAT, Bhubaneswar – 751 003.pp: 178-199.

Yadav, A.K. (2010). Training Manual on Certification and Inspection Systemsin Organic Farming in India. National Centre of Organic FarmingCGO-II, Kamla Nehru Nagar, Ghaziabad, UP – 201 002.

CHAPTER 5

Package of Practices

State wise package of parctices are given in this chapter.

CHHATISGARH

Suggested cropping systems for organic production (based on testing under NPOF)

1. Soybean-chickpea
2. Soybean-onion
3. Rice-chickpea

Details of crops in cropping systems

Soybean

Particulars	*Kharif*
Crop	Soybean
Sowing/planting	Second fortnight of June
Harvesting	Second fortnight of October
Variety	JS-335

Important features of suitable variety

Variety	JS-335
Duration (days)	95-100
Average yield under organic condition (kg/ha)	1500-1800
Source (s) of availability	National Seed Project – IGKV, Raipur
Suitable regions/districts in the state	Kabirdham, Durg, Rajnandgaon, Bemetra,Raipur and parts of Bilaspur districts.
Specific resistance / tolerance to pest	Tolerance to stem fly
Specific resistance / tolerance to disease	Resistance to bacterial pustule and tolerance to bud blight

Field preparation: One deep ploughing followed by two harrowing and planking.

Cultural practices

Seed rate (kg/ha)	70-75		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium culture	500 g/ha	Seed treatment
	PSB	500 g/ha	Seed treatment
	Tricoderma viridi culture	500 g/ha	Seed treatment
Spacing (row × plant) in cm	30 × 10		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity/ha**	
	FYM	2 tonnes	
	Vermicompost	0.8 tonnes	
	Neemcack	0.2 tonnes	
	Rock phosphate	0.27 tonnes	
Major weeds	Motha (*Cyperus spp*.), Crab grass (*Digitaria sanguinalis*), Jangali kodo – Goose grass *(Eleusine indica),* Sava – Barnyard grass (*Echinochloa colona*), Badi dudhi – Garden spurge (*Euphorbia hirta*), Dudhi – Milkweed (*Euphorbia geniculata*), Hazardana – Seed-under-leaf (*Phylanthus niruri*)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-25 DAS	Hand weeding and mechanical weeding by cycle wheel hoe	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Tobacco caterpillar	*Baveriya basiyana* SLNPV 500 L.E.	4 gm/litre of water 2 ml/litre of water

Yield

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean
Economic yield (kg/ha)	1603	2385	2793	2448	1623	1556	1695	1081	1718	1878

Chickpea

Important features of suitable variety *Rabi*

Variety	Vaibhav
Duration (days)	110-115
Average yield under organic condition (kg/ha)	800-1000
Source (s) of availability	IGKV, Mega seed Project
Suitable regions/districts in the state	Chhattisgarh plains
Specific resistance / tolerance to disease	Wilt resistance

Field preparation: Ploughing through cultivator twice and planking

Cultural practices

Seed rate (kg/ha)	70-80		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium	0.5 kg	Seed treatment
	PSB	0.5 kg	Seed treatment
Spacing (row X plant) in cm	30 × 10		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity/ha**	
	FYM	1.33 tonnes	
	Vermicompost	0.53 tonnes	
	Neemcack	0.13 tonnes	
	Rock phosphate	0.27 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Flowering and pod filling.	2-3
Major weeds	Bathua - Lambsquarters (*Chenopodium album*), Safed senji - White sweet clover (*Melilotus alba*), Krishna neel - Scarlet pipmpernel (*Anagallis arvensis*), Chinouri - Medick (*Medicago denticulate),* Sava - Barnyard grass *(Echinochloa colona)*, Motha (*Cyperus spp.*)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25-30 DAS	Hand weeding or hand hoe/cycle hoe	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Gram pod borer	HaNPV	250 LE/ha 3 spray at weekly interval.
		Trichogramma spp.	50000 eggs/ha
		Pheromone trap	5-8 nos.

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	Mean
Economic yield (kg/ha)	770	1480	1090	610	957	981

Neem cake

Vermicopost

F.Y.M.

Kharif

Organic soybean growth stage

Rabi

Organic chickpea pod setting stage

Kharif

Organic soybean before harvesting

Rabi

Organic chickpea

Onion

Particulars	***Rabi***
Crop	Onion
Sowing/planting	First fortnight of December
Harvesting	First fortnight of April
Variety	Nasik red

Important features of suitable variety

Variety	**Nasik Red**
Duration (days)	100-110
Average yield under organic condition (kg/ha)	8000-12000
Source (s) of availability	Raipur Local Market
Suitable regions/districts in the state	Chhattisgarh plains

Nursery raising practices

Area of nursery required for 1 ha	500 m^2		
Nursery raising method	raised bed method		
Bed size (length X breadth in m)	5 × 1		
Seed sowing rate/m^2	20 g		
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^2area**	**Method of application**
	Vermicompost	200 g	Soil incorporation
	FYM	500 g	Soil incorporation
Irrigation practices	First come up Irrigation after sowing and next 7-10 days interval		
Weed management	One hand weeding 25-30 days after sowing		
Optimum age of nursery (days)	40-45		

Field preparation: One deep ploughing followed by two harrowing and planking applied for field preparation.

Cultural practices

Spacing (row × plant) in cm	15 × 10
Number of seedlings/hill	1

Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	5 tonnes	
	Vermicompost	2 tonnes	
	Neem cake	0.5 tonnes	
	Rock phosphate	0.27 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	6-8	Formation of bulb	3 - 4
Major weeds	Amarbel – Dodder (*Cuscuta spp),* Bathua - Lambsquarters (*Chenopodium album),* Choulai – Green amarenth (*Amaranthus viridis*), Safed senji – White sweet clover (*Melilotus alba*), Sava – Barnyard grass (*Echinochloa colona*), Motha - (*Cyperus spp.*) and Chanori – Medick (*Medicago denticulate*)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-25 and 45-50 DAS	Hand weeding and interculture	
Optimum stage of harvesting	100-110 days		

Yield

Year	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha)	9070	11800	13260	13170	11825

Organic onion produce

Organic onion growth stage

Rice

Particulars	*Kharif*
Crop	Rice
Sowing/planting	Second fortnight of June
Harvesting	First fortnight of November
Variety	Kasturi and Sugundhmati

Important features of suitable varieties

Varieties	Kasturi	Sugandhmati
Duration (days)	120-130	135-140
Average yield under organic condition (kg/ha)	3500-4000	3500-4000
Source (s) of availability	National seed project, IGKV, Raipur	National seed project, IGKV, Raipur
Suitable regions/districts in the state	Chhattisgarh Plain zone	Chhattisgarh Plain zone
Specific resistance / tolerance to pest	Stem borer tolerance	
Specific resistance / tolerance to disease	Blast resistance	

Nursery raising practices

Area of nursery required for 1 ha	1000 m^2		
Nursery raising method	Raised bed method		
Bed size (length X breadth in m)	10 × 1		
Seed sowing rate/m^2	40 g		
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^2 area**	**Method of application**
	Enriched compost	100 g	Soil application
	Cow dung manure	500 g	Soil application
	Non edible oil cake	50 g	Soil application
Irrigation practices			6-7 days interval
Optimum age of nursery (days)	21-25 days		

Field preparation: Sowing of sunhemp should be done during May month for green manuring purpose and incorporated in the field at vegetative stage around 40-45 DAS. For incorporation of the green manure impound the water in the field and after that plough the field twice and use rotavator once for proper incorporation and puddling.

Cultural practices

Spacing (row X plant) in cm	20 × 10		
Number of seedlings/hill (in nursery crops only)	2-3		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**		**Quantity/ha**
	Enriched compost		6.6 tonnes
	Cow dung manure		4.4 tonnes
	N.E.O.C. – Non edible oil cake		0.88 tonnes
	Rock phosphate		0.05 tonnes
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Biodynamic preparation	2.5 g/32.5 lit water	P.I. and flowering stage
	Panchagavvya	50 litre	P.I. and flowering stage
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5-6	Tillerig & grain filling	5-7
Major weeds	Sava – Barnyard grass (*Echinochloa colona, Echinochloa crus-galli*) Motha (*Cyperus spp.*), Kauva keni – Benghal day flower (*Commelina benghalensis), Resham Kanta – Sessil joyweed (Alternanthera sessilis), Kana – Creeping cradle plant (Cynotis axillaris)* etc.		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 DAT and 10-15 days interval thereafter.	Ambika Paddy weeder	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Leaf folder	Neem oil	2 litres

Yield

Year	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha)	3550	4280	4260	4320	4102

Cow dung manure

Neem cake

Organic rice field of NPOF experiment

Organic paddy

HIMACHAL PRADESH

Suggested cropping systems (based on testing under NPOF)

1. Maize-garlic
2. Cauliflower-pea-tomato
3. Coriander-pea-tomato

Details of crops in cropping systems

Maize

Particulars	***Kharif***
Crop	Maize
Sowing/planting	June
Harvesting	October
Variety	Girija

Important features of suitable variety

Variety	**Girija**
Duration (days)	115
Average yield under organic condition (kg/ha)	4603
Source (s) of availability	CSK HPKV, Palampur
Suitable regions/districts in the state	Kullu, Mandi, Chamba
Specific tolerance to drought/water logging	Yes

Field preparation: Irrigate the field and then plough disc harrow and thereafter plough with power tiller twice and thereafter follow planking to maintain proper moisture in the field. Prepare plain beds and keep trenches in between and around the field for water drainage.

Cultural practices

Seed rate (kg/ha)	20-25		
Spacing (row × plant) in cm	60 × 20		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity/ha**	
	FYM	16 tonnes	
	Vermicompost	12 tonnes	
	Rock phosphate	60 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine	60 L/600 L water	30, 45, 60,90 DAS
	Panchagavaya	18 L/600 L water	60,90 DAS
	Vermiwash	60 L/600 L water	60,90 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	4-5	3-4 leaf stage, tasseling, grain filling etc.	4-5
Major weeds	**Local name**	**Common name**	**Scientific name**
	Doob grass	-	Cynadon dactylon
	Motha	Purple nutsedge	*Cyperus* spefies
	Baru	Johnson grass	*Sorghum halepense*
	Jhanda	Water grass	*Echinochloa colonum*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	4 leaf stage, 1 month after first weeding and at tasellling	Manual	

Organic plant protection practices	Name of pest/ disease	Organic material recommended for control	Quantity
	Cut-worms	Through cultural practices like flood irrigation and formation of trenches around the field	4- 5 flood irrigations and digging trench of size 20 cm deep and 20 cm wide
Optimum stage of harvesting	When the cob covering turns brown and the moisture in cobs is near 30%		

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha)	3143	2823	3030	3572	3800	5950	6018	5654	7440	4603

Organic maize

Organic maize growth stage

Garlic

Important features of suitable variety

Variety	**GHC-1**
Duration (days)	220
Average yield under organic condition (kg/ha)	8035
Source (s) of availability	University
Suitable regions/districts in the state	Kullu, Mandi, Solan, Shimla,Kangra
Specific tolerance to drought/water logging	Drought resistant

Field preparation: Irrigate the field to field capacity and then plough once with disc harrow and twice with power tiller and thereafter follow planking to maintain proper moisture in the field. Plain bed size is kept as land availability.

Cultural practices

Seed rate (kg/ha)	500-600		
Spacing (row × plant) in cm	20 × 10		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity/ha**	
	FYM	22 tonnes	
	Vermicompost	16 tonnes	
	Rock phosphate	100 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine	60 L/600 L water	30, 45, 60,90, 120 DAS
	Panchagavaya	18 L/600 L water	60,90, 120 DAS
	Vermiwash	60 L/600 L water	60,90, 120 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5-6	15 DAS, 3 leaf, initiation of clove formation, 30 days before harvesting	4-5
Major weeds	**Local name**	**Common name**	**Scientific name**
	Jaldhar	Corn Butter Cup	*Ranunculus arvensis*

	Poa grass	Annual blue grass	*Poa annua*
	Maina/Khukhni	Bur clover	*Medicago denticulate*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	3 leaf, clove formation, 35 days before harvesting	Manual	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Purple Blotch	Cow urine+ Butter milk	30 L/300 L water/ha+30 L/300 L water/ha
	Stemphylium blight	*Trichoderma viride + Pseudomonas fluorescence*	0.30 gm/m^2 each
Optimum stage of harvesting	When leaf colour changes to yellow and starts drying		

Yield

Year	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**Mean**
Economic yield (kg/ha)	6082	4420	4600	9000	9640	9640	8644	10840	9450	8035

Organic garlic crop in field

Organic garlic

Cauliflower

Particulars	***Kharif***
Crop	Cauliflower
Sowing/planting	August
Harvesting	October
Variety	Hybrid- Swati

Important features of suitable variety

Variety	**Hybrid-Swati**
Duration (days)	70
Average yield under organic condition (kg/ha)	8852
Source (s) of availability	Local Market
Suitable regions/districts in the state	Kullu and Mandi

Nursery raising practices

Area of nursery required for 1 ha	30 m^2		
Nursery raising method	Raised seed bed		
Bed size (length × breadth in m)	3m × 1m		
Seed sowing rate/m^2	23g		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2 area**	**Method of application**
	Nursery bed treatment		
	Trichoderma virde/ Trichoderma harzianum	40 gm/ m^2	Drenching/ broadcasting
	Plastic sheet	22 m^2	Soil solarisation
	Seed treatment		
	Trichoderma virde	5 gm/kg of seed	Seed coating
	Pseudomonas fluorescence	5 gm/kg of seed	
	Hot water Treatment for black rot		Seed soaking

Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^{2}area**	**Method of application**
	FYM	5 kg	Basal application
	Vermicompost	2 kg	-do-
Irrigation practices	Watering can		
Weed management	Manual		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/ m^2 area**
	Blight/leaf spot	*Trichoderma virde + Pseudomonas fluorescence*	0.30 gm/m^2 each
	Black rot	*Trichoderma virde + Pseudomonas fluorescence*	0.30 gm/m^2 each
	Curd rot	*Trichoderma virde + Pseudomonas fluorescence*	0.30 gm/m^2 each
Optimum age of nursery (days)	38		

Field preparation: The field is irrigated and then plough once with disc harrow and thrice with power tiller to bring soil in to good tilth. The bed size is kept as per convenience.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Seedling treatment		
	Trichoderma virde	3kg/ha	Root dip
	Pseudomonas fluorescence	3kg/ha	Root dip
Spacing (row × plant) in cm	60 × 45		

Number of seedlings/ kanal (400 m^2)	1480		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity/ha**	
	FYM	22 tonnes	
	VC	16 tonnes	
	Rock phosphate	100 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine	60 L/600 L water	15, 30, 45, 60 DAT
	Panchagavya	18L/600 L water	30, 45, 60 DAT
	Vermi wash-10%	60 L/600 L water/ha	30, 45, 60 DAT
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	4-5	Transplanting and curd formation	4-5 cm
Major weeds	**Local name**	**Common name**	**Scientific name**
	Jhanda	Water grass	*Echinochloa colonum*
	Chhoti Jhan	Yellow foxtail	*Setaria glauca*
	Motha	Purple nutsedge	*Cyperus sp.*
	Ragi/Mandal	Goose grass	*Eleusine indica*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	2-3 (4 leaf stage, 2 times before curd formation)	Manual	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	1. *Lepidopeterus* larvae	Delta Sticky Traps having DBM (Diamond Back Moth) lure to be installed	25traps/ha

		immediately after transplanting	
	2. Aphids	No need as the population remains below Economic Injury Level	-
Optimum stage of harvesting (in case of vegetables and green cob)	When curds become compact and gain proper shape		

Yield

Year	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha)	10670	9660	8330	9523	7570	7360	8852

Organic cauliflower crop

Organic cauliflower curds

Pea

Important features of suitable variety

Variety	**Azad P-1**
Duration (days)	140
Average yield under organic condition (kg/ha)	8941
Source (s) of availability	Deptt. of Agriculture
Suitable regions/districts in the state	Kullu

Field preparation: Irrigate the field to field capacity and then plough once with disc harrow and twice with power tiller and thereafter follow planking to maintain proper moisture in the field. Plain bed size is kept as land availability.

Cultural practices

Seed rate (kg/ha)	75		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Soil treatment		
	Trichoderma virde	3.75 kg/ha	Broadcast
	Seed Treatment		
	Trichoderma virde	3.75 kg/ha	Seed coating of each
	Pseudomonas fluorescence	3.75 kg /ha	
Spacing (row × plant) in cm	60 × 10		
Basal application of organic	**Source**	**Quantity/ha**	
manures including soil	FYM	4.34 tonnes	
application of bio-fertilizers,	Vermicompost	3.2 tonnes	
bio-control agents etc	Rock phosphate	87 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine	60L	30, 45, 60 DAS

	Panchagavya	18L	30, 45, 60 DAS
	Vermi wash-10%	60 L/600 L water/ha	30, 45, 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2-3	Seed germination, flowering and pod formation	4-5cm
Major weeds	**Local name**	**Common name**	**Scientific name**
	Jaldhar	Corn Butter Cup	*Ranunculus arvensis*
	Poa grass	Annual blue grass	*Poa annua*
	Maina/Khukhni	Bur clover	*Medicago denticulate*
	Krishan neel	Scarlet pimpernel	*Anagallis arvensis*
	Khokhua	Chick weed	*Stellaria media*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	1. After 3-4 weeks of sowing 2. Before flowering	Manual	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Ascochyta blight	*Trichoderma virde + Pseudomonas fluorescence*	3kg/ha each
	Powdery mildew	Ginger, Garlic and Chilli Extract	1.25 kg/ha ginger, 2.5 kg/ha garlic, 1.25 kg/ha chilli
	Powdery mildew	*Trichoderma virde + Pseudomonas fluorescence*	3kg/ha each
Optimum stage of harvesting (in case of vegetables and green cob)	When Pea pods attain dark green colour		

Yield (kg/ha) of pea in cropping systems

Year	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Cauliflower-**pea**-tomato	10820	11290	5230	7420	10185	8700	8941
Corainder-**pea**-tomato			6485	5941	7150	4248	5956

Organic vegetable pea crop

Organic green pods

Organic green pods

Tomato

Important features of suitable variety

Variety	**Hybrid- 7730**
Duration (days)	85
Average yield under organic condition (kg/ha)	10411
Source (s) of availability	Department of Agriculture & local market
Suitable regions/districts in the state	Kullu, Mandi, Kangra, Solan
Specific resistance / tolerance to pest	No
Specific resistance / tolerance to disease	Bacterial wilt
Specific tolerance to drought/waterlogging	No

Nursery raising practices

Area of nursery required for 1 ha	30 m^2		
Nursery raising method	Raised seed bed		
Bed size (length × breadth in m)	3m × 1 m		
Seed sowing rate/m^2	15 g		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2area**	**Method of application**
	Seed Treatment		
	Trichoderma virde	5 gm/kg each	Seed coating
	Pseudomonas fluorescence		
	Nursery bed Treatment:		
	Trichoderma virde / Trichoderma harzianum	40 gm/ m^2	Drenching/ broadcasting
	Plastic sheet	30m^2	Soil solarisation
	Seedling Treatment		
	Trichoderma virde	0.30 g/m^2 each	Root dip
	Pseudomonas fluorescence		

Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^{2}area**	**Method of application**
	FYM	2 kg	Basal application
	Vermicompost	1 kg	-do-
Irrigation practices	Watering can		
Weed management	Manual		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/ m^{2}area**
	Blights/leaf spots/fruit rots	*Trichoderma virde*+ *Pseudomonas fluorescence*	0.30 gm/m^2 each
	Wilt/root/collar rot	*Trichoderma virde* as soil treatment	3.75kg/m^2
	Wilt/root/collar rot	*Trichoderma virde* + *Pseudomonas fluorescence* as foliar spray	0.30 gm/m^2 each
Optimum age of nursery (days)	32		

Field preparation: The field is irrigated and then plough once with disc harrow and thrice with power tiller to bring soil in to good tilth. The bed size is kept as per convenience. Proper trenches around the field are formed for drainage of excess water.

The land holding in the state is generally small and it is difficult to use tractor for ploughing. In such situation, the ploughing may be done preferably with bullocks or power tiller.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Trichoderma viride+ *Pseudomonas flourosence*	3.75kg/ha each	Basal application

Spacing (Row × plant) in cm	60 × 45		
Number of seedlings/ kanal (400m^2)	1480		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity/ha**	
	FYM	17.4 tonnes	
	Vermicompost	12.8 tonnes	
	RP	100 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine	60 L/600 L water	15, 30, 45, 60 DAT
	Panchagavya	18L/600 L water	15, 30, 45, 60 DAT
	Vermiwash	60 L/600 L water	15, 30, 45, 60 DAT
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3-4	Transplanting, flowering and fruit setting	4-5
Major weeds	**Local name**	**Common name**	**Scientific name**
	Kulfa	Purslane	*Portulaca oleracea*
	Tipatia/khatibuti	Wood sorrel	*Oxalis latifolia*
	Poa grass	Annual blue grass	*Poa annua*
	Peeli buti	-	*Gallinsoga parviflora*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	After 2-3 weeks of transplanting and thereafter 45 and 60 DAT	Manual	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Fruit borer	i) Lipel/Dipel (*Bacillus thuringiensis sp. kurstaki*)	Lipel @1.0 kg/ha or Dipel 1.0 L/600 L/ water/ha

	ii) Neemban(0.15%)	3L/600 L water/ ha
	iii) Margosom (Azedarchtin 1.0%)	0.6L/600 L water/ ha
	iv) *Darek (Melia *azedarach*) or Karvi (*Roylea cinerea*) or kali basuti (*Eupatorium*) 5% aqueous leaf extract + cow urine 3% + emulsifier TritonX-100 (0.05%)	3L/600 L water/ ha
Optimum stage of harvesting	When ¼th lower part of tomato fruit turns red.	

Yield (kg/ha) of tomato in cropping systems

Year	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Cauliflower-pea-**tomato**	14970	15620	18580	1993	3700	7600	10411
Corainder-pea-**tomato**			24635	8086	3328	8555	11151


Organic tomato crop


Organic tomato fruits

Coriander

Particulars	*Kharif*
Crop	Coriander
Sowing/planting	August
Harvesting	September
Variety	Mediterranea- Hybrid

Important features of suitable variety

Variety	Mediterranea- Hybrid
Duration (days)	91
Average yield under organic condition (kg/ha)	6507
Source (s) of availability	Local Market
Suitable regions/districts in the state	Kullu

Field preparation: Irrigate field and then plough once with disc harrow and thrice with power tiller to bring soil in to fine tilth. Plain beds are made keeping bed size as per convenience.

Cultural practices

Seed rate (kg/ha)	20 kg		
Spacing (row × plant) in cm	30 x 5		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity/ha**	
	FYM	13 tonnes	
	Vermicompost	8 tonnes	
	Rock phosphate	65 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine	60 L/600 L water	30, 45, 60 DAS
	Bio dynamic (501)	2.5 g/40 L	45 and 60 DAS
	Panchagavya	18L/600 L water	30, 45, 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5-6	-	4-5 cm

Major weeds	**Local name**	**Common name**	**Scientific name**
	Jhanda	Water grass	*Echinochloa colonum*
	Chhoti Jhan	Yellow foxtail	*Setaria glauca*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	After 2-3 weeks of sowing	Manual	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	No insect-pest problem found, hence no need of plant protection practices		
Optimum stage of harvesting	After 4-5weeks, twice at 15-20 days interval		

Yield

Year	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha) (green leaf)	6396	9523	3512	6596	6507

Organic green coriander crop

Harvested organic coriander

Process


FYM


Vermicompost


Vermiwash as nutrient supplement


Phermone trap


Water trap


Yellow sticky trap


Leaf extract-*Roylea cinerea*


Leaf extract-*Melia azedarach*


Trichoderma, Pseudomonas & Lipel


Neembaan


5% Melia, 1% Morgosom and 5% Eupatorium

JHARKHAND

Suggested cropping systems (based on testing under NPOF)

1. Rice (basmati type)-wheat
2. Rice (basmati type)-lentil
3. Rice (basmati type)-linseed
4. Rice (basmati type)-potato

Rice

Particulars	***Kharif***
Crop	Rice
Sowing/planting	Transplanting in 1st fortnight of July
Harvesting	1st fortnight of Nov.
Variety	Birsamati

Important features of suitable variety

Variety	**Birsamati**
Duration (days)	125-135 (Medium)
Average yield under organic condition (kg/ha)	3000-3500 kg/ha
Source (s) of availability	AICRP on RiceBAU, Ranchi.
Suitable regions/districts in the state	All district/Jharkhand
Specific resistance / tolerance to pest	Gall midge
Specific resistance / tolerance to disease	Bacterial leaf and sheath blight

Nursery raising practices

Area of nursery required for 1 ha	1000m^2
Nursery raising method	Dry nursery

Bed size (length × breadth in m)	1 × 10m^2		
Seed sowing rate/m^2	35 kg/ha		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^{2}area**	**Method of application**
	Pseudomonas fluorescence	5g/kg of seed	For seed dressing metal seed dresser / earthernpots or polythene bags are used
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^{2}area**	**Method of application**
	FYM	1/2 kg	Soil application at the time of nursery preparation 10-15 days prior to sowing.
	Vermicompost	1/4 kg	Applied along with soil after sowing to cover the seeds.
Irrigation practices	As and when needed		
Weed management	1 Hand weeding		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/ m^{2}area**
	Wilt, Blast, Blight	Nisarga/Monitor/ Biosanjeevni (Trichoderma viride)	Seed- 5 g/litre/kg
Optimum age of nursery (days)	25-30 days		

Field preparation: The field was ploughed twice 15 days before transplanting the puddling of the soil was done two days prior to transplanting. The green manure crop dhaincha can be grown at seed rate of 40 kg/ha in May month with application of 250 kg/ha of rock phosphate. The dhaincha crop has to be incorporated at 40-45 DAS at 15 days prior to rice transplanting. This will able to meet out the 25-30 kg/ha of nitrogen requirement of paddy crop.

Cultural practices

Spacing (row X plant) in cm	20x10 cm		
Number of seedlings/hill	2 seedlings/hill		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity (q/ha)**	
	FYM	53.28 q	
	Karanj cake	6.66 q	
	Azolla	1 kg/m^2	
Top dressing of organic manures	**Source**	**Quantity (q/ha)**	**Days after sowing/ planting or stage of crop**
	Vermicompost	26.66	15 DAT
	Panchagavya	10-12 lit/ha mixed in 500-600 litre of water	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Need based	Tiller initiation, flowering and milky stage	3-5 cm standing water
Major weeds	**Local Name**	**English Name**	**Scientific Name**
	Motha	Nut sedge	*Cyperus difformis*
	Dub ghas	Couch grass	*Cynodon dactylon*
	Sawa	Water grass	*Echinochloa colona*
	Kodo	Goose grass	*Eleusine indica*
	Bhangra, Bhangaraiya	False daisy	*Eclipta alba*
	Bara-nagar-motha	Flat sedge	*Cyperus iria*
	Kankaua	Day flower	*Commelina benghalensis*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-25 & 40-45 DAT	Hand weeding and summer ploughing	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	White ant, grubs	Kalichakra (metarhizium aniopliae)	Soil- 1-2 kg/40 kg FYM/acre foliar-1 kg/ kg jaggery in 200 litre/acre

	Soil born disease	Trichoderma viride	Vermicompost should be treated with Trichoderma to grow its mycelium and treated vermicompost in used
	Sheath blight and sheath rot	Pseudomonas fluorescence	10 gm/litre of water
	Stem borer	Trichocard	8 trichocard/ha (2 times)
	Blight and false smut	Neem or Karanj cake	500 kg/ha at the time of transplanting
	Blast	Bael+Black Tulsi	25 gm each in 1 litre of water
	Most of the insects leaf folder, stem borer, Gandhi bug	Neem seed kernel extract or Neem oil	Foliar 3-5 ml/litre

Yield

Year	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**	**6th year**	**7th year**	**Mean**
Economic yield (kg/ha)	1970	1880	3191	3396	3945	3305	4050	2717

Rice 100% organic

Rice 100% organic

Wheat

Important features of suitable variety

Variety	**K-9107**
Duration (days)	130
Average yield under organic condition (kg/ha)	2000-2500
Source (s) of availability	AICRP on wheat
Suitable regions/districts in the state	All district/Jharkhand
Specific resistance / tolerance to disease	Leaf blight

Field preparation: For field preparation of wheatone deep ploughing followed by 2 -3 harrowing with disc or tines and 2-3 planking should be given to prepare a well pulverised seed bed. Planking should be done after each ploughing.

Cultural practices

Seed rate (kg/ha)	125 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	PSB & Azotobacter	250gm/10 kg seeds each	Warm the water and add 100 gm of jiggery. Mix it well and allow to cool and then add azotobacter culture in it. Finally seed is well mixed with azotobacter culture solution. The treated seed is allowed to dry in shade. Similarly the seed is again treated with PSB and finally sowing is done
Spacing (row x plant) in cm	Row 20cm		
Basal application of organic	**Source**	**Quantity (q/ha)**	
manures	FYM	66.66	
	Karanj cake	8.33	

Top dressing of organic manures	**Source**	**Quantity (q/ha)**	**Days after sowing/ planting or stage of crop**
	Vermicompost	33.33	25-30 DAS
	Panchagavya	10-12 lit/ha mixed in 500-600 lit of water	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	6	Crown root initiation, tillering, jointing, booting, flowering, milk and dough stages	5-6cm
Major weeds	**Local name**	**English name**	**Scientific name**
	Krishananeel	Red pimpernel	*Anagallis arvensis*
	Kateli	Bull thistle	*Cirsium arvense*
	Bathu	Common lambsquarters	*Chenopodium album*
	Motha	Nut sedge	*Cyperus difformis*
	Gehusa (gehu ka mama)	Canary grass	*Phalaris minor*
	Dub ghas	Couch grass	*Cynodon dactylon*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-25 & 40-45	Hand weeding and stale seed bed technique	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	White ant, grubs	Kalichakra (metarhizium aniopliae)	Soil- 1-2 kg/40 kg FYM/acre foliar-1 kg/ kg jaggery in 200 litre/ acre

	Most of the insects	Neem oil (Multinimore Vanguard)	Foliar 2.5ml/litre
	Soil born disease	*Trichoderma viride*	Vermicompost should be treated with Trichoderma to grow its mycelium and treated vermicompost in used
	Black rust, brown rust, yellow rust and leaf blight	*Trichoderma herginum* + *Pseudomonas fluorescence*	5 g/litre of water
	Loose smut	*Trichoderma herginum* or *Trichoderma viride*	Seed treatment 5 g/kg seed

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Mean**
Economic yield (kg/ha)	2048	2366	2528	2587	2000	1875	2240	1950	4399

Wheat crop under towards organic approach

Wheat organic crop

Details of Specific Practices

Panchgavya preparation method

Panchgavya can be prepared by mixing 3 litre of cow urine, 5 kg of cow dung, 2 litre of cow milk, curd of 2 litres of cow milk, 1 kg cow ghee, 5 litre water, 500 gm honey, 1 kg jaggery in earthen pot. Then the earthen pot is covered and left for 3 weeks. The prepared Panchgavya should be used only after sieving the material, about 2 litre of Panchgavya should be well mixed in 100 litre of water and sprayed to the crop plants. The prepared Panchgavya would be sufficient 1.5ha of land.

Lentil

Particulars	***Rabi***
Crop	Lentil
Sowing/planting	2nd fortnight ofNov.
Harvesting	2nd fortnight of March.
Variety	PL-406

Important features of suitable variety

Variety	**PL-406**
Duration (days)	115
Average yield under organic condition (kg/ha)	600-800
Source (s) of availability	Directorate of Seed & Farm, BAU.
Suitable regions/districts in the state	All district of Jharkhand
Specific resistance / tolerance to disease	moderately resistant wilt and rust

Field preparation: For field preparation of lentil one deep ploughing followed by 2-3 cross harrowing should be given. After harrowing, the field should be levelled by giving a gentle slope to ease in irrigation.

Cultural practices

Seed rate (kg/ha)	25-30 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	PSB & Rhizobium culture	250 g/10 kg seeds	Warm the water and add 100 gm of

			jiggery. Mix it well and allow to cool and then add rhizobium culture in it. Finally seed is well mixed with rhizobium culture solution. The treated seed is allowed to dry in shade. Similarly the seed is again treated with PSB and finally sowing is done
Spacing (row × plant) in cm	25 x 8cm		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity(q/ha)**	
	FYM	14.0	
	Karanj cake	2.0	
Top dressing of organic manures	**Source**	**Quantity(q/ha)**	**Days after sowing/ planting or stage of crop**
	Vermicompost	7.0	25-30 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Pre-flowering stage	5-6
Major weeds	**Local name**	**English name**	**Scientific name**
	Krishananeel	Red pimpernel	*Anagallis arvensis*
	Kateli	Bull thistle	*Cirsium arvense*
	Bathu	Common lambsquarters	*Chenopodium album*
	Motha	Nut grass	*Cyperus difformis*
	Dub ghas	Bermuda grass	*Cynodon dactylon*
	Kheshari	Sweet pea	Lathyrus odoratus
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-25 & 40-45	Hand weeding and stale seed bed technique	

Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	White ant, grubs	Kalichakra (metarhizium aniopliae)	Soil- 1-2 kg/40 kg FYM/acre foliar-1 kg/ kg jaggery in 200 litre/acre
	Most of the insects	Neem oil (Multinimore Vanguard)	Foliar 2.5 ml/litre
	Soil borne disease	*Trichoderma*	FYM or Vermicompost treated with *trichoderma* and applied to the field

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Mean**
Economic yield (kg/ha)	650	735	920	750	562	0	770	649	630

Lentil under organic + innovative practice combination

Lentil organic crop

Linseed

Particulars	***Rabi***
Crop	Linseed
Sowing/planting	2nd fortnight ofNov.
Harvesting	1st fortnight of April.
Variety	Shekhar

Important features of suitable variety

Variety	**Shekhar**
Duration (days)	140
Average yield under organic condition (kg/ha)	500-700
Source (s) of availability	Directorate of seed & farm, BAU.
Suitable regions/districts in the state	All district/Jharkhand
Specific resistance / tolerance to pest	Moderately resistant to bud fly
Specific resistance / tolerance to disease	Resistant to powdery mildew, rust, wilt and moderately resistant to alternaria blight

Field preparation: Field should be prepared by giving one ploughing by soil turning plough followed by 2-3 harrowing and finally planking.

Cultural practices

Seed rate (kg/ha)	25-30 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	PSB & Azotobacter	250 g/10 kg seeds each	Warm the water and add 100 gm of jaggery. Mix it well and allow to cool and then add *azotobacter* culture in it. Finally seed is well mixed with *azotobacter* culture

			solution. The treated seed is allowed to dry in shade. Similarly the seed is again treated with PSB and finally sowing is done
Spacing (row × plant) in cm	Row 30cm		
Number of seedlings/hill (in nursery crops only)	-		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity (q/ha)**	
	FYM	26.66 q	
	Karanj cake	3.33 q	
Top dressing of organic manures	**Source**	**Quantity (q/ha)**	**Days after sowing/ planting or stage of crop**
	Vermicompost	13.33	25-30 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Three irrigation at 35, 55 and 75 days after sowing proved very effective	5-6 cm
Major weeds	**Local name**	**English name**	**Scientific name**
	Krishananeel	Red pimpernel	*Anagallis arvensis*
	Kateli	Bull thistle	*Cirsium arvense*
	Bathu	Common lambsquarters	*Chenopodium album*
	Motha	Nut grass	*Cyperus difformis*
	Dub ghas	Bermuda grass	*Cynodon dactylon*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-25 & 40-45	Hand weeding and stale seed bed technique	

Organic plant protection practices	Name of pest/ disease	Organic material recommended for control	Quantity
	White ant, grubs	Kalichakra (metarhizium aniopliae)	Soil- 1-2 kg/40 kg FYM/acre foliar-1 kg/ kg jaggery in 200 litre/acre
	Most of the insects	Neem oil (Multinimore Vanguard)	Foliar 2.5 ml/litre
	Soil born disease	*Trichoderma*	*Trichoderma* powder mixed with vermicompost of FYM to develop its mycelium and applied to whole field

Yield

Year	1st*	2nd	3rd	4th	5th	6th	7th	8th	Mean
Economic yield (kg/ha)	492	350	420	400	550	700	790	795	562

Linseed under organic production system

Linseed organic crop

Potato

Particulars	***Rabi***
Crop	Potato
Sowing/planting	2nd fortnight of Nov.
Harvesting	2nd fortnight of Feb.
Variety	Kufri Ashoka

Important features of suitable variety

Variety	**Kufri Ashoka**
Duration (days)	95
Average yield under organic condition (kg/ha)	18000-20000
Source (s) of availability	Ram Krishna Mission, Ranchi
Suitable regions/districts in the state	All district/Jharkhand

Field preparation: Land should be well prepared by deep ploughing with mould-bold plough followed by 3-4 cross harrow wings. Each harrowing should be followed by planking so that the soil is well pulverised and levelled.

Cultural practices

Seed rate (kg/ha)	300 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	PSB & Azotobacter	250 g/10 kg seeds	Warm the water and add 100 gm of jaggery. Mix it well and allow to cool and then add *azotobacter* culture in it. Finally seed is well mixed with *azotobacter* culture solution. The treated seed is allowed to dry in shade. Similarly the seed is again treated with PSB and finally sowing is done

Spacing (row × plant) in cm	Row to row 50cm, tuber to tuber 20cm		
Basal application of organic manures including soil application of bio-fertilizers, bio-control agents etc	**Source**	**Quantity (q/ha)**	
	FYM	80.0 q	
	Karanj cake	10.0 q	
Top dressing of organic manures	**Source**	**Quantity (q/ha)**	**Days after sowing/ planting or stage of crop**
	Vermicompost	40.0	25-30 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	4-5	1st irrigation at 4-5 days after seeding than after 10 days interval	5-6 cm
Major weeds	**Local name**	**English name**	**Scientific name**
	Krishananeel	Red pimpernel	*Anagallis arvensis*
	Kateli	Bull thistle	*Cirsium arvense*
	Bathu	Common lambsquarters	*Chenopodium album*
	Motha	Nut grass	*Cyperus difformis*
	Dub ghas	Bermuda grass	*Cynodon dactylon*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-25 & 40-45	Hand weeding and stale seed bed technique	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	White ant, grubs	Kalichakra (metarhizium aniopliae)	Soil- 1-2 kg/40 kg FYM/acre foliar-1 kg/ kg jaggery in 200 litre/acre
	Most of the insects	Neem oil (Multinimore Vanguard)	Foliar 2.5 ml/litre
	Black Scurf	*Trichoderma* treated Neem cake	Soil application @ 5 q/ha

Yield

Year	1st*	2nd	3rd	4th	5th	6th	7th	8th	Mean
Economic yield (kg/ha)	9110	17283	19500	20500	19166	18750	19000	19300	17826

Linseed with 75 % supply of nutrients through organic manures and innovative practices under organic production system

Potato under organic system

Wheat under towards organic approach

Lentil under towards organic approach

KARNATAKA

Suggested cropping systems (based on testing under NPOF)

1. Soybean-wheat
2. Groundnut-sorghum
3. Chilli+cotton
4. Maize-chickpea

Details of crops in cropping systems

Soybean

Particulars	*Kharif*
Crop	Soybean
Sowing/planting	June I Fortnight
Harvesting	September II Fortnight
Varieties	JS-335, JS 9305, DSB 21

Important features of suitable varieties

Varieties	JS-335	JS 9305	DSB 21
Duration (days)	85-90	80-85	85-90
Average yield under organic condition (kg/ha)	2000-2500	2000-2500	2000-2500
Source (s) of availability	Bio-Resource Farm, IOF, UAS, Dharwad	Bio-Resource Farm, IOF, UAS, Dharwad	Bio-Resource Farm, IOF, UAS, Dharwad
Suitable regions/ districts in the state	Belgaum, Bidar, Dharwad, Haveri, Bagalkot	Belgaum, Bidar, Dharwad, Haveri, Bagalkot	Belgaum, Bidar, Dharwad, Haveri, Bagalkot

Specific resistance / tolerance to disease	Resistant to bacterial pustules and leaf spot diseases	-	Resistant to rust disease
Specific tolerance to drought/ waterlogging	Drought	Drought	Drought

Field preparation: Prepare land to a fine tilth by cultivating and harrowing (Deep poughing once in three years in medium deep to deep black soils and every year shallow black and red soils followed by 2 to 3 harrowing). Apply organic manures FYM/Compost and green leaf manures at 10-15 days before sowing. Apply vermicompost and neemcake at the time of sowing.

Cultural practices

Seed rate (kg/ha)	75 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium	1 kg/ha	Seed treatment
	PSB	1 kg/ha	Seed treatment
	Trichoderma harzianum	0.5 kg/ha	Seed treatment
Spacing (row x plant) in cm	30 x 7.5 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Enriched compost	3.33 tonnes	
	Vermicompost	2.66 tonnes	
	Green leaf manure	5.33 tonnes	
	Neem cake	250 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Cow urine @ 10%	100 litre/ha	Foliar spray at 30 and 45 days after sowing

	Panchagavya @3 %	30 litre/ha	Foliar spray at 30 and 45 days after sowing
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Purely under	Rainfed condition	
Major weeds	*Digitaria marginata Dinebra retroflexa, Pannicum Spp., Cynodon dactylon, Commelina subulata, Commelina benghalensis, Cyanotis cucullata, Euphorbia Spp., Eleusine indica, Echinochloa colonum, Setaria Spp, Cyperus rotundus, Parthenium justerophorus, Sida acuta and Portulaca oleracea*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 to 35 days after sowing	Deep tillage, stale seed bed preparation. Inter cultivation with hoes and mechnical hand weeder (20 and 40 DAS (days after sowing) and manual weeding (at 25 and 45 DAS)	
Organic plant protection practices	**Name of pest/disease**	**Organic material**	**Quantity**
		recommended for control	
1. Sprinkle seeds of castor or sunflower for spodoptera management	Defoliators and pod borer	Botanicals @ 5% foliar spray at 65 DAS	25 litres
2. Collection of eggmasses/ early instar larvae from infected plants.		NSKE neem seed karnel extract @ 5% at 55 DAS	50 litres 1 kg
3. Pheromone traps@ five / ha for monitoring of S. *litura.*		*Nomuraea rileyi* 10^{11} conidia/ha @ 1 g/lit at 55 DAS	

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Economic yield (kg/ha)	2003	1310	1464	1876	1968	1993	2809	3227	2081

Wheat

Particulars	*Rabi*
Crop	Wheat
Sowing/planting	October II Fortnight
Harvesting	February II Fortnight
Varieties	DWR-2006, Bijaga Yellow

Important features of suitable varieties

Varieties	DWR 2006	Bijaga Yellow
Duration (days)	105-110	105-110
Average yield under organic condition (kg/ha)	1200-1500	1200-1500
Source (s) of availability	Bio-Resource Farm, IOF, UAS, Dharwad	Bio-Resource Farm, IOF, UAS, Dharwad
Suitable regions/districts in the state	Entire Karnataka State	Entire Karnataka State
Specific resistance / tolerance to disease	Resistant to leaf blotch	Resistant to leaf blotch
Specific tolerance to drought/waterlogging	Drought	Drought

Field preparation: After harvest of soybean crop one or two harrowing are taken to bring soil to a find tilth. Apply organic manures (Green leaf manure) 15 days before sowing. Apply vermicompost and neemcake at the time of sowing.

Cultural practices

Seed rate (kg/ha)	50 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azospirillum	0.5 kg	Seed treatment
	PSB	0.5 kg	Seed treatment
	Trichoderma harzianum	0.25 kg	Seed treatment
Spacing (row x plant) in cm	30 row spacing		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Enriched compost	2.00 tonnes	
	Vermicompost	1.70 tonnes	
	Green leaf manure	3.30 tonnes	
	Neem cake	250 kg	

Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine @ 10%	100 litre/ha	Foliar spray at 30 days after sowing and at boot leaf stage
	Panchagavya @ 3%	30 litre/ha	Foliar spray at 30 after sowing and at boot leaf stage
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Purely under Rainfed condition		
Major weeds	*Argemone mexicana, stachytarpheta indica, celosia argentea*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 to 35 DAS	Inter cultivation with hoes (20 and 40 DAS) and manual weeding (at 30 and 50 DAS)	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Aphids and sucking pests	NSKE @ 5%	250 litres
		Botinacal Mixer @ 10 %	500 litres
		verticillium lecanii @ 1 g/litre	0.5 kg
	Termites	Application of Calatrophis leaves to soil at the time of sowing	-

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Economic yield (kg/ha)	903	996	1265	1370	969	983	1364	1137	1123

Organically grown Soybean in soybean-wheat sequence cropping

Organically grown Wheat in soybean-wheat sequence cropping

Groundnut

Particulars	*Kharif*
Crop	Groundnut
Sowing/planting	June I Fortnight
Harvesting	September II Fortnight
Varieties	GPBD-4, JL 24

Important features of suitable varieties

Varieties	GPBD-4	JL 24
Duration (days)	105 to 110	105 to110
Average yield under organic condition (kg/ha)	3000-3500	3000-3500
Source (s) of availability	Bio-Resource Farm, IOF, UAS, Dharwad	Bio-Resource Farm, IOF, UAS, Dharwad
Suitable regions/ districts in the state	Districts of Northern Karnataka	Districts of Northern Karnataka
Specific resistance / tolerance to disease	Resistant to leaf spot and rust diseases	-
Specific tolerance to drought/waterlogging	Drought	Drought

Field preparation: Prepare land to a fine tilth by cultivating and harrowing (Deep poughing once in three years in medium deep to deep black soils and every year in shallow black and red soils followed by 2 to 3 harrowing). Apply organic manures FYM/Compost and green leaf manures at 10-15 days before sowing. Apply vermicompost and neemcake at the time of sowing.

Cultural practices

Seed rate (kg/ha)

GPBD-4	125 kg/ha
JL 24	150 kg/ha

Pre-sowing/planting treatment of seed/seedlings	Material	Recommended rate	Method of application
	Rhizobium	1 kg/ha	Seed treatment
	PSB	1Kg/ha	Seed treatment

	Trichoderma harzianum	0.75 kg/ha	Seed treatment
Spacing (row x plant) in cm	30 x 10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Enriched compost	3.00 tonnes	
	Vermicompost	2.40 tonnes	
	Green leaf manure	5.00 tonnes	
	Neem cake	250 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Cow urine @ 10%	100 litres	Foliar spray at 45 and 60 days after sowing
	Panchagavya @ 3%	30 litres	Foliar spray at 45 and 60 days after sowing
	Gypsum	500 kg	Apply at 35 to 40 days after sowing to the plant rows and earthing up will be done.
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Purely under Rainfed condition		
Major weeds	*Digitaria marginata Dinebra retroflexa, Pannicum Spp., Cynodon dactylon, Commelina subulata, Commelina benghalensis, Cyanotis cucullata, Euphorbia Spp., Eleusine indica, Echinochloa colonum, Setaria Spp, Cyperus rotundus, Parthenium justerophorus, Sida acuta and Portulaca oleracea*		

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	25 to 35 DAS	Deep tillage, stale seed bed preparation. Inter cultivation with hoes and mechnical hand weeder (25 and 40 DAS (days after sowing) and manual weeding (at 30 DAS)

Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
● Growing setaria or bajra as intercrop at 7:1 row proportion and castor as trap crop for S. *litura* management. ● Use of pheromone traps @ 5 per hectare for monitoring of *S. litura.* ● Collection of eggmasses of S. *litura* in groundnut as they lay eggs on upper surface of leaves	Defoliators	NSKE neem seed karnel extract @ 5% or custard apple leaf extract @ 5% at 45 and 60 DAS	100 litres
		Nomuraea rileyi 10^{11} conidia /ha @ 1 g/lit at 45 and 60 DAS	2 kg/ha

Yield

Year	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**Mean**
Economic yield (kg/ha)	3448	1721	2142	3064	3232	4247	4520	3683	3257

Sorghum

Particulars	***Rabi***
Crop	Sorghum
Sowing/planting	October
Harvesting	February II Fortnight
Varieties	M35-1, DSV-4

Important features of suitable varieties

Varieties	**M-35-1**	**DSV-4**
Duration (days)	120-125	115-120
Average yield under organic condition (kg/ha)	1200-1500	1200-1500
Source (s) of availability	Bio-Resource Farm, IOF, UAS, Dharwad	Bio-Resource Farm, IOF, UAS, Dharwad
Suitable regions/districts in the state	Districts of Northern Karnataka	Districts of Northern Karnataka
Specific resistance / tolerance to pest	Resistant to shoot fly	-
Specific resistance / tolerance to disease	-	Resistant to charcoal rot disease
Specific tolerance to drought/waterlogging	Drought	Drought

Field preparation: After harvest of Groundnut crop one or two harrowing are taken to bring soil to a find tilth. Apply organic manures 15 days before sowing. Apply vermicompost and neemcake at the time of sowing.

Cultural practices

Seed rate (kg/ha)	7.5 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azospirillum	0.5 kg/ha	Seed treatment
	PSB	0.5 kg/ha	Seed treatment
	Trichoderma harzianum	0.03 kg/ha	Seed treatment
Spacing (row x plant) in cm	45 x 15		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Enriched compost	2.00 tonnes	
	Vermicompost	1.70 tonnes	

	Green leaf manure Neem cake	3.30 tonnes 250 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Cow urine @ 10 %	100 litres	Foliar spray at 30 and 45 DAS
	Panchagavya @ 3%	30 litres	Foliar spray at 30 and 45 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Purely under Rainfed condition		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 to 35 DAS	Inter cultivation with hoes (25, 50 and 60 DAS) and manual weeding (at 30 DAS)	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Shoot fly Sucking pests	NSKE @ 5% at 25 DAS	50 litres
	Aphids	Foliar application of Verticillium lecanii @ 2 g/lit	1 kg
		Botinacal Mixer @ 10 %	50 litres

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Economic yield (kg/ha)	1119	1088	1296	1146	1080	1060	1532	1178	1187

Organically grown Groundnut in groundnut-sorghum sequence cropping

Organically grown Sorghum in groundnut-sorghum sequence cropping

Chilli

Particulars	*Kharif*
Crop	Chilli
Sowing/planting	June I Fortnight
Harvesting	December II Fortnight
Varieties	Byadagi Kaddi, Byadagi dabbi Dyvanur

Important features of suitable varieties

Varieties	Byadagi Kaddi	Byadagi dabbi	Dyvanur
Duration (days)	180-200	180-200	180-200
Average yield under organic condition (kg/ha)	750-1000	750-1000	750-1000
Source (s) of availability	Bio-Resource Farm, IOF, UAS, Dharwad	Bio-Resource Farm, IOF, UAS, Dharwad	Bio-Resource Farm, IOF, UAS, Dharwad
Suitable regions/ districts in the state	Districts of Northern Kartnataka	Districts of Northern Kartnataka	Districts of Northern Kartnataka
Specific tolerance to drought/waterlogging	Drought	Drought	Drought

Nursery raising practices

Area of nursery required for 1 ha	135 Square meter		
Nursery raising method	Raised bed method		
Bed size (length x breadth in m)	7.5m length and 1.20m.width		
Seed sowing rate/m^2	0.3 kg / m^2		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2 area**	**Method of application**
	Azospirillum	250 g	Seed treatment
	PSB	250 g	Seed treatment
	Trichoderma harzianum	10 g	Seed treatment
Source and optimum quantity of organic manures/other	**Materials**	**Quantity/ m^{2}area**	**Method of application**
	FYM	5.56 /m^2 area	
	Vermicompost	2.78 /m^2 area	

Irrigation practices	Water the beds once in two days and stop watering 2-3 days before planting (27-28 DAS).
Weed management	Hand weeding
Optimum age of nursery (days)	30 days old

Field preparation: Prepare land to a fine tilth by cultivating and harrowing (Deep poughing once in three years in medium deep to deep black soils and every year in shallow black and red soils followed by 2 to 3 harrowing). Apply organic manures FYM/Compost and green leaf manures at 10-15 days before sowing. Apply vermicompost and neemcake at the time of sowing.

Cultural practices

Seed rate (kg/ha)	3 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azospirillum PSB Trichoderma	250 g 250 g 10 g	Seed treatment Seed treatment Seed treatment
Spacing (Row x plant) in cm	60cm x 60cm		
Number of seedlings/hill	Two seedlings/hill		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Enriched compost Vermicompost Green leaf manure Neem cake	4.20 tonnes 3.30 tonnes 6.70 tonnes 250 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Cow urine @ 10%	150 lit/ha	Foliar spray at 45, 60 and 75 DAS
	Panchagavya @ 3%	45 lit/ha	Foliar spray at 45, 60 and 75 DAS

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Purely under Rainfed condition		

Major weeds

Digitaria marginata Dinebra retroflexa, Pannicum Spp., Cynodon dactylon, Commelina subulata, Commelina benghalensis, Cyanotis cucullata, Euphorbia Spp., Eleusine indica, Echinochloa colonum, Setaria Spp, Cyperus rotundus, Parthenium justerophorus, Sida acuta and Portulaca oleracea

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	25 to 35 DAS	Deep tillage, stale seed bed preparation. Inter cultivation with hoes and mechnical hand weeder (30,45 and 60 DAS (days after sowing) and manual weeding (at 35 and 50 DAS)

Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
❖ Barrier crop of maize or jowar 4-6 rows all along the border of chilli field to prevent sucking pest like thrips and mites and encourage natural enemies.	Sucking pest	NSKE neem seed karnel extract @ 5% or Verticillium lecanii at 30 and 45 DAT	50 lit/ha 2 kg/ha
❖ Plant one row of marigold for every 15 rows of chilli as trap crop for *H.armigera* management.	Fruit borer	NSKE (neem seed karnel extract) @ 5% Or Chilli + garlic extract @ 2% at 60 and 90 DAT (days after transplanting)	50 lit/ha 20 lit/ha
❖ Use Pheramone traps @ 5/ha for monitoring of *H.armigera.* ❖ Use yellow sticky traps @ 10/acre for management of sucking pests	Anthracnose and fruit rot	Foliar spray of *Pseudomonas fluorescence* @ 5 g/l of water.	25 g/kg

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	Mean
Economic yield (kg/ha)	318	250	604	646	418	447

Cotton

Particulars	*Rabi*
Crop	Cotton
Sowing/planting	August I Fortnight
Harvesting	February I Fortnight
Variety	Jayadhar

Important features of suitable variety

Variety	Jayadhar
Duration (days)	200 days
Average yield under organic condition (kg/ha)	500-600
Source (s) of availability	Bio-Resource Farm, IOF, UAS, Dharwad
Suitable regions/districts in the state	Entire Karnataka State
Specific tolerance to drought/waterlogging	Drought

Cultural practices

Seed rate (kg/ha)	3 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Cow Urine @ 25%	50 lit/ha	Soak the seeds in 25% cow urine solution and air dried
	Azospirillum	0.5 kg/ha	Seed treatment
	PSB	0.5 kg/ha	Seed treatment
Spacing (row x plant) in cm	60 x30		
Number of seedlings/hill	Dibble two cotton seeds per hill between two chilli plants in a row		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Enriched compost	3.30 tonnes	
	Vermicompost	2.70 tonnes	
	Green leaf manure	5.30 tonnes	
	Neem cake	250 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Cow urine @ 10 %	100 lit/ha	Foliar spray at 60 and 75 DAS

	Panchagavya @ 3%	30 lit/ha	Foliar spray at 60 and 75 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Purely under Rainfed condition		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 to 35 DAS	Inter cultivation with hoes (25, 35 and 50 DAS) and manual weeding (at 30 and 55 DAS)	
Organic plant protection	**Name of pest/disease practices**	**Organic material recommended for control**	**Quantity**
• Use marigold and bhendi as trap crops for management of bollworm and shoot weevil. • Maize as border crop • Use of pheromone traps @ 5 per ha for monitoring of *H.armigera.* • Yellow sticky trap for management of whiteflies @ 10 /acre. • Release of trichocard @ 1 card/acre at weekly interval 8-10 times after square formation.	Sucking pests	Botanical mixer @ 5% spray at 30 and 60 DAS	50 lit/ha
	Bollworm	NSKE @ 5% foliar spray @ 90 and 105 DAS	50 lit/ha

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	Mean
Economic yield (kg/ha)	553	518	529	889	316	561

Organically grown Chilli in Cotton sequence cropping

Organically grown Cotton in Groundnut - Sorghum sequence cropping

Maize

Particulars	***Kharif***
Crop	Maize
Sowing/planting	June I Fortnight
Harvesting	September II Fortnight
Variety	EH-434042 (Arjun)

Important features of suitable variety

Variety	**EH-434042 (Arjun)**
Duration (days)	110-115
Average yield under organic condition (kg/ha)	3000-3500
Source (s) of availability	Bio-Resource Farm, IOF, UAS, Dharwad
Suitable regions/ districts in the state	Entire Karnataka State

Field preparation: Prepare land to a fine tilth by cultivating and harrowing (Deep poughing once in three years in medium deep to deep black soils and every year in shallow black and red soils followed by 2 to 3 harrowing). Apply organic manures FYM/Compost and green leaf manures at 10-15 days before sowing. Apply 50 % vermicompost and entire quantity neemcake at the time of sowing and remaining 50% Vermicompost has .to be applied at 30 DAS.

Cultural practices

Seed rate (kg/ha)	15 kg		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azospirillium	1 kg/ha	Seed treatment
	PSB	1 kg/ha	Seed treatment
Spacing (row x plant) in cm	60 cm x 30		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Enriched compost	4.20 tonnes	
	Vermicompost	3.30 tonnes	
	Green leaf manure	6.70 tonnes	
	Neem cake	250 kg	

Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Cow urine @ 10%	100 lit/ha	Foliar spray at 30 and 45 days after sowing
	Panchagavya @ 3%	30 lit/ha	Foliar spray at 30 and 45 days after sowing
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Purely under Rainfed condition		
Major weeds	*Digitaria marginata Dinebra retroflexa, Pannicum Spp., Cynodon dactylon, Commelina subulata, Commelina benghalensis, Cyanotis cucullata, Euphorbia Spp., Eleusine indica, Echinochloa colonum, Setaria Spp, Cyperus rotundus, Parthenium justerophorus, Sida acuta and Portulaca oleracea*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 to 35 DAS	Deep tillage, stale seed bed preparation. Inter cultivation with hoes and mechnical hand weeder (20 and 40 DAS (days after sowing) and manual weeding (at 25 and 45 DAS)	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
• Plant NB 21 grass on the bunds as a trap crop for management of stem borer of maize. • Release of *Trichogram* @ 50000/ha (1 card/ha) at weekly interval 3 to 4 times to control stem borer.	Cob borer	*Nomuraea rileyi* @ 1 g/lit or HaNPV	0.5 kg/ha 250 LE/ha
	Aphids and Stem borer	Neem seed kernel extract @ 5% or Botanicals @ 10% spray at 45 and 60 DAS	50 lit/ha
	Armyworm	NSKE 5% and *Nomuraea rileyi* @ 1 g /l of water	25 lit/ha 0.5 kg/ha

Yield

Year	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Economic yield (kg/ha)	1955	3113	3002	4280	4700	3410

Chickpea

Particulars	***Rabi***
Crop	Chickpea
Sowing/planting	October II Fortnight
Harvesting	February II Fortnight
Varieties	Annigeri-1, JG-11

Important features of suitable varieties

Varieties	**Annigeri-1**	**JG-11**
Duration (days)	90-95	90-100
Average yield under organic condition (kg/ha)	1200-1500	1200-1500
Source (s) of availability	Bio-Resource Farm, IOF, UAS, Dharwad	Bio-Resource Farm, IOF, UAS, Dharwad
Suitable regions/districts in the state	Districts of Northern Karnataka	Districts of Northern Karnataka
Specific resistance / tolerance to disease	-	Resistant to wilt
Specific tolerance to drought/water logging	Drought	Drought

Field preparation: After harvest of Maize crop one or two harrowing are taken to bring soil to a find tilth. Apply organic manures 15 days before sowing. Apply vermicompost and neemcake at the time of sowing.

Cultural practices

Seed rate (kg/ha)	50 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium	1 kg/ha	Seed treatment
	PSB	1 kg/ha	Seed treatment
	Trichoderma harzianum	125 g/ha	Seed treatment

Spacing (row x plant) in cm	30 x 10		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Enriched compost	1.00 tonnes	
	Vermicompost	8.0 quintal	
	Green leaf manure	1.70 tonnes	
	Neem cake	250 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Cow urine @ 10 %	100 lit/ha	Foliar spray at 30 and 45 DAS
	Panchagavya @ 3%	30 lit/ha	Foliar spray at 30 and 45 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Purely under Rainfed condition		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 to 35 DAS	Inter cultivation with hoes (25, 50 and 60 DAS) and manual weeding (at 30 DAS)	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Pod borer	Ha NPV +Neem Seed Kernel Extract @5% orChilli + garlic extract @ 2% ● Intercropping of coriander at 4:1 row ratio help to reduce pod borer.	250 LE/ha 25 lit/ha 10 lit /ha

- Monitoring of *Helicoverpa* by pheromone traps @ 5/ha.
- For attraction of birds, sprinkle puffed rice or cooked rice with turmeric powder in the morning or evening hours.
- Barrier crop of sorghum all along the border of chickpea reduce rust incidence

Yield

Year	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Economic yield (kg/ha)	807	1292	954	1534	964	1110

Organically grown Maize in maize-chickpea sequence cropping

Organically grown Chickpea in maize-chickpea sequence cropping

KERALA

Suggested cropping systems (based on testing under NPOF)

1. Turmeric-fallow
2. Ginger-fallow
3. Black pepper

Based on testing by ICAR-CTCRI, Thiruvananthapuram

4. Elephant foot yam + green manure (cowpea)
5. Green manure cowpea-yams + green manure (cowpea)
6. Taro + green manure (cowpea)

Turmeric

Particulars	***Kharif***
Crop	Turmeric
Sowing/planting	April-May
Harvesting	December-January
Varieties	IISR Alleppey Supreme, IISR Prathibha

Important features of suitable varieties

Varieties	**IISR Prathibha**	**IISR Alleppey Supreme**
Duration (days)	225	210
Average yield under organic condition (kg/ha)	3670 (18360 fresh)	3620 (18080 fresh)
Source (s) of availability	IISR	IISR
Suitable regions/districts in the state	Kerala, Karnataka, Tamilnadu, Andhra Pradesh	Kerala, Karnataka, Tamilnadu, Andhra Pradesh
Specific resistance /tolerance to disease	Nil	Shows tolerance to leaf blotch disease

Field preparation

The land is prepared with the receipt of early monsoon showers. The soil is brought to a fine tilth by giving about four deep ploughings. If the pH is less than 6, hydrated lime or dolomite @ 1000 kg/ha has to be applied for laterite soils and thoroughly ploughed. Immediately with the receipt of pre-monsoon showers, beds of 1.0 m width, 30 cm height and of convenient length are prepared with spacing of 50 cm between beds. Planting is also done by forming ridges and furrows.

Cultural practices

Seed rate (kg/ha)	2000-2500 Kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	PGPR strain of GEB 17 developed by IISR	cfu 10^7 for suppressing diseases.	50 g/ bed as talc formulation
Spacing (row x plant) in cm	25 x 25 cm		
Number of seedlings/hill	40 plants/ 3 x 1 m ginger beds		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	20 tonnes	
	Neem Cake	2 tonnes	
	Composted coir pith enriched with and suitable microbial cultures of *Azospirillum* and phosphate solubilizing bacteria	5 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Vermicompost	2 tonnes	45th and 90th DAP
	Ash	0.5 tonnes	45th and 90th DAP
	Turmeric specific micronutrient mixture (Restricted use)	5 g/litre of water	Foliar spray may be sprayed 60 and 90 days after planting

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Rainfed	Tillering, Rhizome development stage	
Major weeds	*Ageratum conyzoides* (goat weed)-Kattappa *Spermacoce latifolia* (button weed) *Oldenlandia auricularia* (dapoli weed)-Padarpaka pullu *Cleome rutidosperma* (fringed spider flower)-Naivela *Oxalis corniculata* (Creeping wood sorrel)-Puliyarila		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	45 &90 DAP	Mulching with locally available material like coconut leaf, paddy straw etc	
Organic plant protection	**Name of pest/disease practices**	**Organic material recommended for control**	**Quantity**
	Shoot borer	Neem oil/ neem gold	5 ml per liter water, foliar spray
	Rhizome rot	Bordeaux mixture 1%.	Foliar spray
Optimum stage of harvesting	180-225 days after planting		

Yield

Year	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Economic yield (t/ha)						
Fresh	15.65	12.43	27.52	28	10.1	18.74
Dry	3.13	2.49	5.50	5.60	2.02	3.74

Ginger

Important features of suitable varieties

Varieties	IISR Varada	IISR Rejatha	IISR Mahima
Duration (days)	200	200	200
Average yield under organic condition (kg/ha)	13870 kg fresh 2777 kg dry	12940 kg fresh 2590 kg dry	13500 kg fresh 2700 kg dry
Source (s) of availability	IISR	IISR	IISR
Suitable regions/districts in the state	Kerala, Karnataka	Kerala, Karnataka	Kerala, Karnataka
Specific resistance / tolerance to disease	Nil	Nil	Tolerant to root knot nematode

Field preparation: The land is to be ploughed 4 to 5 times or dug thoroughly with receipt of early summer showers (April) to bring the soil to fine tilth. If pH of the soil is less than 6, hydrated lime/ dolomite @ 1 ton/ha may be applied at the time of last plough to the soil. Beds of about 1 m width, 30 cm height and of convenient length (3m) are prepared with an inter-space of 50 cm in between beds. In the case of irrigated crop, ridges are formed 40 cm apart. In areas prone to rhizome rot disease and nematode infestations, solarization of beds for 40 days using transparent polythene sheets is recommended. Application of *Trichoderma harzianum*, *Bascillus, Pseudomonas fluorescens* along with neem cake @ 1 kg/bed reported to be suppressive to soil born pathogens.

Cultural practices

Seed rate (kg/ha)	2000 Kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	PGPR strain of GRB-35 solution developed by IISR for enhancing growth and suppressing diseases.	1 capsule/ 100 lit of water. For 1 ha 20 capsule	Seed rhizome dipping in PGPR strain solution for 1 hour
Spacing (row x plant) in cm	25 x 25 cm		
Number of seedlings/hill	40 plants/ 3 x 1 m ginger beds		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	20 tonnes	
	Composted coir pith enriched with and suitable microbial cultures of *Azospirillum* and phosphate solubilizing bacteria	4 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Vermicompost	2 tonnes	45th and 90th DAP
	Ash	0.5 tonnes	45th and 90th DAP

	Ginger specific micronutrient mixture (Restricted use)	5g/litre of water	Foliar spray may be sprayed 60 and 90 days after planting
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Rain fed	Tillering, Rhizome development stage	20 cm
Major weeds	*Ageratum conyzoides* (goat weed)-Kattappa *Spermacoce latifolia* (button weed) *Oldenlandia auricularia* (dapoli weed)-Padarpaka pullu *Cleome rutidosperma* (fringed spider flower)-Naivela *Oxalis corniculata* (Creeping wood sorrel)-Puliyarila		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	45 & 90 DAP	Mulching with locally available material like dried coconut leaves 5400 kg/ha at the time of planting ,one season old paddy straw 6t/ha +green leaf 7.5 t/ha each at 45 & 90 DAP etc.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Shoot borer	Neem oil/ neem gold	5ml per liter water foliar spray
	Soft rot and bacterial wilt	Bordeaux mixture 1%.	Spray & drenching
Optimum stage of harvesting	200 Days after Planting.		

Yield

Year	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Economic yield (t/ha)						
Fresh	18.9	8.21	13.5	20	7.5	13.6
Dry	3.78	1.64	2.70	4.0	1.50	2.72

Black Pepper

Important features of suitable varieties

Varieties	**Karimunda**	**Panniyur-1**
Duration (days)	perennial	perennial
Average yield under organic condition (kg/ha)	1.00 t/ha	1.34 t/ha
Source (s) of availability	IISR	IISR
Suitable regions/districts in the state	Kerala, Karnataka, Tamilnadu	Kerala, Karnataka, Tamilnadu

Nursery raising practices

Area of nursery required for 1 ha	Three month old rooted cuttings 2000 nos (2 each per standard tree)		
Nursery raising method	Rooted cuttings produced through serpentine method in 20x10 cm poly bags filled with nursery mixture(2:1:1) under shade/poly house of suitable size 24 x 6m		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2area**	**Method of application**
	Potting mixture		Solarized prior to use.
	Trichoderma harzianum	1g/kg potting mixture	Mixing with potting mixture prior to use
Source and optimum quantity of organic manures/other nutrient source of nursery	**Materials**	**Quantity**	**Method of application**
	Cowdung	Should be mixed with soil,sand 2:1 proportion	Mixture should be Filled in polythene bags by manually
Irrigation practices	Daily during summer, once in alternate day during rainy season		

Organic plant protection practices	Name of pest/disease	Recommended organic material used for control	Quantity/ m^2area
	Shoot borer/thrips	Neem oil	5ml/liter
	Phytophthora foot rot	Bordeaux Mixture	1% foliar spray
	Root knot nematode	*Pochonia chlamydosporia*	2 gm/kg potting mixture
Optimum age of nursery (days)	Three months old rooted cuttings with 3-4 leaf stage is ready for field planting		

Field preparation: Pits of 50 cm^3 may be taken at a distance of 30-45 cm from the standard (support) and has to be filled with a mixture of 3-5 kg of well rotten FYM/compost, 125g rock phosphate, 500 g neem cake and 50 g of *Trichoderma harzianum* mixed with the top soil for better establishment of rooted cuttings.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	Material	Recommended rate	Method of application
	Trichoderma harzianum mixed with composted coffee husk waste or tea waste or cowdung/ neem cake	50 g inoculam mixed with 2 kg compost/vine /year	May be applied around the basins of black pepper at the time of planting
Spacing (row x plant) in cm	3 x3 m		
Number of seedlings/hill	Two rooted cuttings of black pepper plant/pit.		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	10 tonnes Basal	
	Neem Cake	1 tonnes Basal	
	Such compost can be further supplemented with neem cake enriched with suitable microbial	1 kg/vine/year	

	cultures of *Azospirillum* and phosphate solubilizing bacteria that are native to the environment. Foliar application of micronutrient mixture specific to black pepper developed by ICAR-IISR is also recommended (dosage @)		
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Ash	1 tonnes	September-October
	Leaf/vermicompost	2 tonnes	September-October
	Black pepper specific micronutrient mixture (restricted use)	5 g/L water	Foliar spray during flowering and after one month
	36 irrigation per year	Flowering and spike initiation for adult vine, alternate days for younger plants in summer	30 cm
Major weeds	*Ageratum conyzoides* (goat weed)-Kattappa *Peperomia pellucida* (silver bush)-Mazhithandu *Spermacoce latifolia* (button weed) *Oldenlandia auricularia* (dapoli weed)-Padarpaka pullu		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	June-July	Hand weeding	

Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Pollu beetle	Shade regulation, Neem gold	6 ml/liter may be applied at 2-3 weeks interval
	Scale insects	Clipping of infected branches	Spraying neem gold 0.6% and fish oil rosin 3%
	Phytophthora Foot rot	*Trichoderma harzianum*	Mixing with suitable carrier medium such as coffee husk compost/tea waste, cow dung etc during May-June @ 5 kg/vine (to supply 50 g/ vine inoculum) and a second round application of the same quantity during August-September.
	Fungal pollu	Spraying Bordeaux mixture during September-october	1% foliar spray.
	Nematode	Biocontrol agent like *Pochonia chlamydosporia*	May be applied 50 g/vine twice a year (during April-May and September-October) to control nematode problems.
Optimum stage of harvesting	Six month after planting, during harvesting the whole spike is to be handpicked when one or two berries in the spike turn bright orange red.		

Yield

Year	2007-08	2008-09	2009-10	Mean
Economic yield (t/ha)				
Dry	1.75	0.91	1.01	1.20


Turmeric under organic system


Ginger under organic system


Black pepper under organic production

Elephant foot yam

Details of crops in cropping systems

Particulars	***Kharif***	***Rabi***	**Summer**
Crop	Elephant foot yam and green manure cowpea taken during summer continues	Elephant foot yam taken during summer continues	Elephant foot yam + green manure cowpea
Sowing/planting			I fortnight of March planting elephant foot yam and sowing cowpea
Harvesting	First fortnight of May harvesting and incorporating green manure cowpea	First fortnight of January harvesting elephant foot yam	
Varieties			Elephant foot yam: Gajendra, Sree Padma, Sree Athira, Peerumade local, Vegetable and Fruit Promotion Council Keralam (VFPCK): local, Green manure (cowpea): C-152

Important features of suitable varieties

Varieties	**Gajendra**	**Sree Padma**	**Sree Athira**	**Peerumade local**	**VFPCK local**
Duration (days)	240-270	240-270	240-270	240-270	240
Average yield under organic condition (t/ha)	33.69	28.85	23.26	26.71	26.09
Source (s) of availability	ICAR-CTCRI	ICAR-CTCRI	ICAR-CTCRI	Locally from Peerumade Development Society (PDS), Pothupara, Idukki dt., Kerala	Vegetable and Fruit Promotion Council Keralam (VFPCK)

Suitable regions/ districts in the state	Throughout the state	Throughout the state	Throughout the state	Throughout the state	Throughout the state

Field preparation: The land is ploughed to a depth of 15-20 cm and levelled. Pits of 60 cm x 60 cm x 45 cm size may be dug 90 cm apart. The topsoil is to be collected up to a depth of 15-20 cm separately and filled in the pits. FYM : neem cake mixture (10:1) incubated with *Trichoderma* is applied @ 3 kg pit^{-1} (36 t/ha) and mixed with topsoil. Neem cake is applied @ 1.0 t/ha (80 g/pit) at the time of planting. Corm pieces of 500 g with a portion of terminal bud treated with slurry containing cowdung, neem cake and *Trichoderma harzianam* (5g/kg seed) are planted in the pits. Immediately after planting elephant foot yam, green manure cowpea is sown @ 20 kg ha^{-1}.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Bio-control agent Cowdung slurry mixed with neem cake and *Trichoderma harzianum*	*Trichoderma* 5 g/kg seed	Seed treatment
Spacing (row X plant) in cm	90 cm x 90 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM + neem cake mixture (10:1) inoculated with *Trichoderma harzianum* (2.5 kg/ tonne of FYM: neem cake mixture)	36 tonnes	
	Neem cake	1 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Green manuring with cowpea	20 – 25 tonnes	45-60 DAP
	Ash	3 t/ha	45-60 DAP (at the time of incorporation of green manure cowpea)

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Rainfed. Life saving irrigation at twice per week until sprouting, if prolonged dry spell occurs.		
Major weeds	*Muthanga*-Purplenutsedge-*Cyperus rotundus*, Thazhuthama-Spreading hog weed-*Boerhaavia diffusa*, Kattukaduku-Wild mustard-*Cleome viscosa*, Wild Indigo- Kozhinjil-*Tephrosia purpurea*, Muyal chevian-Red tassel flower- *Emilia sonchifolia*, Poovamkurunnu-Purple fleabane-*Vernonia cinerea*, Kurumthotti-Common wire weed-*Sida acuta*, Kurumthotti-Sida hemp-*Sida rhombifolia*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	45 DAP and 75 DAP	Mulching immediately after planting and two hand weedings at 45 days and one month later	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Collar rot	FYM: Neem cake mixture (10:1) inoculated with *Trichoderma harzianum*	*Trichoderma* (@ 2.5 kg/tonne of FYM: neem cake mixture) @ 90 kg/ha
		Seed treatment with cowdung slurry mixed with neem cake and *Trichoderma harzianum*	*Trichoderma* (@ 5 g/kg seed) @ 31.25 kg/ha
Optimum stage of harvesting	8-9 months		

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Mean**
Economic yield (t/ha)	65.87	70.63	56.95	57.23	34.81	57.10

Cowdung: neem cake mixture inoculated with *Trichoderma harzianum*

Cost-effective practice of green manuring

Elephant foot yam + green manure cowpea

View of the experiment on organic farming of elephant foot yam

Organic elephant foot yam corms

Yams

Particulars	***Kharif***	***Rabi***
Crop	Yams and green manure (cowpea)	Yams continue
Sowing/planting	I fortnight of May planting yams and sowing green manure cowpea	
Harvesting	II fortnight of June harvesting and incorporation of green manure cowpea	First fortnight of January harvesting yams

Important features of suitable varieties

Varieties	**White yam**	**Greater yam**	**Lesser yam**	**Dwarf white yam**
	Var. Sree Priya	**Var. Sree Keerthi**	**Var. Sree Latha**	**Var. Sree Dhanya**
Duration (days)	270 – 300	270 – 300	210-240	210-240
Average yield under organic condition (t/ha)	22.21	21.96	16.83	13.23
Source (s) of availability	ICAR-CTCRI	ICAR-CTCRI	ICAR-CTCRI	ICAR-CTCRI
Suitable regions/ districts in the state	Throughout the state	Throughout the state	Throughout the state	Throughout the state

Field preparation: The land is ploughed to a depth of 15-20 cm. Pits of 45 x 45 x45 cm size is opened for planting greater yam and white yam at a spacing of 90 x 90 cm. Three-fourths of the pit is filled with top soil and FYM and reformed into mound. For raising lesser yam, mounds may be formed at a spacing of 75 x 75 cm after broadcasting FYM. In the case of greater yam and white yam, tuber pieces of 250-300 g size can be used as planting material. For planting lesser yam, medium sized tuber of 100-150 g is sufficient.

Cultural practices

Seed rate (kg/ha)			
Spacing (row X plant) in cm	White yam and greater yam : 90 x 90 cm Lesser yam: 75 x 75 cm Dwarf white yam: 60 x 60 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	15 tonnes	
	Neem cake	1 tonnes	
	Biofertilizers		
	Azospirillum	3 kg	
	Mycorrhiza	5 kg	
	Phosphobacteria	3 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Green manuring with cowpea	15-20 tonnes	45-60 DAP
	Ash	1.5 tonnes	45-60 DAP (at the time of incorporation of green manure cowpea)
Major weeds	Muthanga-Purplenutsedge-*Cyperus rotundus* Karuka-Bermuda grass-*Cynodon dactylon* Thazhuthama- Spreading hog weed-*Boerhaavia diffusa* Muyal chevian-Red tassel flower- *Emilia sonchifolia* Poovamkurunnu-Purple fleabane-*Vernonia cinerea* Kurumthotti-Common wire weed-*Sida acuta*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	45 DAP and 75 DAP	Mulching immediately after planting and two hand weedings at 45 days and one month later	
Optimum stage of harvesting	White yam and greater yam: 9-10 months Lesser yam and dwarf white yam: 7-8 months		

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**Mean**
Economic yield (kg/ha)							
White yam	17.81	27.16	28.34	18.56	19.22		22.22
Greater yam	19.47	26.30	17.29	21.67	25.07	46.45	26.05
Lesser yam	8.59	24.95	23.57	10.92	16.12	19.28	17.24
Dwarf white yam	12.60	12.28	14.79	16.38			14.02

Taro

Particulars	***Kharif***	***Rabi***
Crop	Taro and green manure cowpea	Taro continues
Sowing/planting	I fortnight of June planting taro and sowing green manure cowpea	
Harvesting	II fortnight of July harvesting and incorporation of green manure cowpea	Second fortnight of November harvesting taro

Important features of suitable varieties

Varieties	**Sree Kiran**	**Sree Rashmi**	**Local**
Duration (days)	190-210	210	210
Average yield under organic condition (t/ha)	10.36	11.19	10.36
Source (s) of availability	ICAR-CTCRI	ICAR-CTCRI	VFPCK
Suitable regions/districts in the state	All regions of the state	All regions of the state	All regions of the state

Field preparation: The land is ploughed to a depth of 20-25 cm. Ridges and furrows are formed at 60 cm spacing. Cormels are planted at a spacing of 45 cm on the ridges. The cormels may be planted at a depth of 2.5-7.5 cm. About 37,000 cormels are required to plant one hectare. Approximately 800 kg of cormels is required to plant one hectare.

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**Mean**
Economic yield (t/ha)	10.43	16.51	9.71	6.93	9.49	18.18	11.86

Glimpses of Production Practices

Yams + green manure cowpea

View of the experiment on Organic farming of yams (trailing genotypes)

View of the experiment on organic farming of dwarf white yam

Green manure cowpea in between dwarf white yam mounds

Organic white yam

Organic greater yam

Organic lesser yam

Organic dwarf white yam

View of the experiment on Organic farming of taro

Green manure cowpea in between taro

Organic taro (var. Sree Kiran)

Organic taro (var. Sree Rashmi)

Organic taro (Local var)

Taro under organic condition

Storage of tuber crops

MADHYA PRADESH

Suggested cropping systems (based on testing under NPOF)

1. Soybean-wheat
2. Soybean-mustard
3 Soybean-chickpea
4. Soybean-isabgol/linseed
5. Green manure (sunhemp)-scented rice-durum wheat
6. Scented rice-chickpea-maize (fodder)
7. Scented rice-berseem (fodder+seed)
8. Scented rice-vegetable pea-sorghum (fodder)

Details of crops in cropping system

Soybean

Particulars	***Kharif***
Crop	Soybean
Sowing/planting	July first fortnight
Harvesting	October
Variety	JS-335

Important features of suitable variety

Variety	**JS-335**
Duration (days)	95-100
Average yield under organic condition (kg/ha)	1100
Source (s) of availability	M.P. State Government
Suitable regions/districts in the state	Central Zone (M.P.)
Specific resistance / tolerance to pest	Tolerant to stem fly

Specific resistance / tolerance to disease	Resistant to bacterial blight and tolerant to green mosaic
Specific tolerance to drought/waterlogging	Susceptible to water logging

Field preparation: Two ploughings are necessary before sowing. Wherever necessary, broad bed furrow can be made to avoid water logging.

Cultural practices

Seed rate (kg/ha)	80		
Pre-sowing/planting treatment of seed/seedlings	**Rhizobium culture**	**5g/kg seed**	**Seed treatment**
	Phosphate Solublizing Bacteria (PSB)	5g/kg seed	Seed treatment
	Trichoderma viride	5 g/kg seed	Seed treatment
Spacing (row × plant) in cm	45 × 5 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Cow dung manure (0.95% Nitrogen)	5 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Rock phosphate 100 kg/ha		
	Rainfed crop		
Major weeds	Doodhi Asthma herb (*Euphorbia hirta*), Motha Purple nutsedge (*Cyperus rotundus*)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-30 days after sowing	Hand weeding	

Organic plant protection practices	Name of pest/ disease	Organic material recommended for control	Quantity
	Stem Girdle beetle	Neem oil (10000 ppm) 1% Azadirachtin	1 litre/ ha along with soap solution
	Tobacco caterpillar	Neem oil (10000 ppm) 1% Azadirachtin	1 litre/ ha along with soap solution

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	714	1399	918	1144	2009	2377	1103	1380

Portable compost unit

Vermicompost

A view of organic soybean crop

Organic soybean seeds

Wheat

Important features of suitable variety

Variety	Malwashakti
Duration (days)	135-140
Average yield under organic condition (kg/ha)	3570
Source (s) of availability	M.P. state Govt.
Suitable regions/districts in the state	Malwa region of M.P.
Specific resistance / tolerance to disease	Resistant to rust

Cultural practices

Seed rate (kg/ha)	80-100 kg/ha		
Spacing (row x plant) in cm	22.5 x 5 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Cow dung manure (0.95% Nitrogen)	4.5 tonnes	
	Vermicompost (1.41% Nitrogen)	3.5 tonnes	
	Poultry Manure (2.36% Nitrogen)	1.5 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2-3	Crown root initiation (21 DAS)	30-40
Major weeds	Senji yellow sweet clover (Melilotus indica), Doodhi Asthma herb (Euphorbia hirta), Motha Purple nutsedge(Cyperus rotundus), Bathua Common lambsquarter (Chenopodium album)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-40 days after sowing	Hand weeding	

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	4160	4094	4110	4915	4406	3604	3136	4061

A view of organic wheat crop in the field

Organic wheat

Wheat

Wheat varieties under organic farming

Mustard

Particulars	***Rabi***
Crop	Mustard
Sowing/planting	2nd fortnight of Octber
Harvesting	1st fortnight of March
Variety	Pusa Bold

Cultural practices

Seed rate (kg/ha)	5-6 kg/ha		
Spacing (row x plant) in cm	45 x 10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Cow dung manure (0.95% Nitrogen)	1.5 tonnes	
	Vermicompost (1.41% Nitrogen)	1.7 tonnes	
	Poultry Manure (2.36% Nitrogen)	1 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Flowering stage	30 cm
Major weeds	Nut sedge (Cyperus rotundus),Bathua Common lambsquarter (Chenopodium album) Doodhi Asthma herb (Euphorbia hirta), Motha Purple nutsedge		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	15-30 days after sowing	Hand weeding	

Organic plant protection practices	Name of pest/ disease	Organic material recommended for control	Quantity (kg or litres/ ha)
	Mustard aphid (*Lipaphis erysimi*)	Neem oil (10000 ppm) 1% Azadirachtin	1 litre/ ha with soap solution

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	1470	1421	1898	1948	2106	1142	1948	1705

A view of mustard crop in the organic farming experiment at Bhopal

Organic mustard seeds

Chickpea

Particulars	***Rabi***
Crop	Chickpea
Sowing/planting	2nd fortnight of October
Harvesting	March
Variety	JG-130

Important features of suitable variety

Variety	**JG-130**
Duration (days)	100-120
Average yield under organic condition (kg/ha)	1880
Source (s) of availability	M.P. state Govt.
Suitable regions/districts in the state	Malwa region of M.P.
Specific resistance / tolerance to disease	Resistant to fusarium wilt, moderately resistant to dry root rot
Specific tolerance to drought/waterlogging	Tolerant to helicoverpa

Field preparation: Two ploughings are necessary before sowing of the crops

Cultural practices

Seed rate (kg/ha)	75-80 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium culture	5g/kg seed	Seed treatment
	Phosphate Solublizing Bacteria (PSB)	5g/kg seed	Seed treatment
	Trichoderma viride	2g/kg seed	Seed treatment
Spacing (row x plant) in cm	30 x 10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Cow dung manure (0.95% Nitrogen)	1.7 tonnes	

	Vermicompost (1.41% Nitrogen)	1.3 tonnes	
	Poultry Manre (2.36% Nitrogen)	0.5 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Flowering stage	
Major weeds	Bathua Common lambsquarter (Chenopodium album), Doodhi Asthma herb (Euphorbia hirta), Motha Purple nutsedge(Cyperus rotundus), Doob grass Bermuda grass (*Cynodon dactylon)*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30 days after sowing	Hand weeding	

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Mean**
Economic yield (kg/ha)	1736	1480	1720	1890	3348	1821	2018	2002

A view of chickpea crop in the organic farming experiment at Bhopal

Organic chickpea seeds

Linseed

Particulars	***Rabi***
Crop	Linseed
Sowing/planting	1st fortnight of October
Harvesting	March
Variety	JL-9

Important features of suitable variety

Variety	**JL-9**
Duration (days)	115-120
Average yield under organic condition (kg/ha)	1300
Source (s) of availability	M.P. state Govt.
Suitable regions/districts in the state	Sagar, Damoh Tikamgerh district of M.P.
Specific resistance / tolerance to disease	Resistant to powdery mildew

Field preparation: Two ploughings are necessary before sowing of the crops

Cultural practices

Seed rate (kg/ha)	25-30 kg/ha		
Spacing (row × plant) in cm	30 x 5 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Cow dung manure (0.95% Nitrogen)	3.4 tonnes	
	Vermicompost (1.41% Nitrogen)	1.7 tonnes	
	Poultry Manre (2.36% Nitrogen)	1 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	30 days after sowing	30

Major weeds	Bathua Common lambsquarter (Chenopodium album), Doodhi Asthma herb (Euphorbia hirta), Doob grass Bermuda grass (*Cynodon dactylon)*	
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	20-30 days after sowing	Hand weeding

Yield

Year	1st	2nd	3rd	4th	Mean
Economic yield (kg/ha)	1823	1080	1228	1392	1381


A view of linseed crop in the organic farming experiment

Organic Linseed

Isabgol

Particulars	***Rabi***
Crop	Isbgol
Sowing/planting	1st week of December
Harvesting	March
Variety	GI-2

Important features of suitable variety

Variety	**GI-2**
Duration (days)	115-120
Average yield under organic condition (kg/ha)	1200
Suitable regions/districts in the state	Neemuch Mandsour and ratlam district of M.P.
Specific resistance / tolerance to disease	Resistant to fusarium wilt, moderately resistant to dry root rot
Specific tolerance to drought/waterlogging	Tolerant to helicoverpa

Field preparation: Two ploughings are necessary before sowing of the crops

Cultural practices

Seed rate (kg/ha)	4-5 kg/ha	
Spacing (row x plant) in cm	30 x 5 cm	
Basal application of organic manures	**Source**	**Quantity/ha**
	Cow dung manure (0.95% Nitrogen)	1.2 tonnes
	Vermicompost (1.41% Nitrogen)	0.6 tonnes
	Poultry Manure (2.36% Nitrogen)	0.3 tonnes
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**
	3-4	Immediate light irrigation after sowing

Major weeds	Bathua Common lambsquarter (Chenopodium album), Doodhi Asthma herb (Euphorbia hirta), Motha Purple nutsedge(Cyperus rotundus),Doob grass Bermuda grass (*Cynodon dactylon)*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-25 days after sowing	Hand weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	White Grub	Neem oil (10000 ppm) 1% Azadirachtin	1 litre/ ha with soap solution

Yield

Year	1st	2nd	3rd	4th	Mean
Economic yield (kg/ha)	1180	1126	1226	1249	1195

A view of isbgol crop in the organic farming experiment

Green manure (*sunhemp*)

Particulars	Summer
Crop	Green manure (sunhemp)
Sowing/planting	IInd fortnight of May
Harvesting	IInd fortnight of June
Variety	N 7

Important features of suitable variety

Variety	N-7
Duration (days)	45
Average yield under organic condition (kg/ha)	300 q (fresh weight) & 30 q (dry weight basis)
Source (s) of availability	JNKVV, Jabalpur
Suitable regions/districts in the state	Jabalpur

Field preparation: 1 pass disk, 1 pass cultivator & leveller

Cultural practices

Seed rate (kg/ha)	25		
Spacing (row x plant) in cm	Broadcasting of seeds		
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	6	7 days intervals	10 cm

Yield

Economic yield	300 q (fresh weight) & 30 q (dry weight)

View of green manure (sunhemp)

Collection of green manure crop for chemical analysis

Scented rice

Particulars	***Kharif***
Crop	Scented rice
Sowing/planting	IInd fortnight of June
Harvesting	Ist fortnight of November
Varieties	Pusa Basmati 1, PS 1, PS 3, PS 5

Important features of suitable varieties

Varieties	**Pusa Basmati 1**	**PS 1**	**PS 3**	**PS 5**
Duration (days)	121	120	125	125
Average yield under organic condition (kg/ha)	29	31	32	31
Source (s) of availability	JNKVV, Jabalpur	JNKVV, Jabalpur	JNKVV, Jabalpur	JNKVV, Jabalpur
Suitable regions/districts in the state	Jabalpur, Rewa	Jabalpur, Rewa	Jabalpur, Rewa	Jabalpur, Rewa

Nursery raising practices

Nursery raising method	Raised bed method		
Bed size (length x breadth in m)	10 m x 1 m		
Seed sowing rate/m^2	100 g/m^2		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2 area**	**Method of application**
	Vermiwash & Cow urine	2.50 ml/m^2 & 1.25 ml/m^2	Spray
	PSB & Azotobactor	5 g/kg & 5 g/kg	Seed inoculation
	Pseudomonas	5 g/kg	Seed inoculation
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^{2}area**	**Method of application**
	Vermicompost	200 g/m^2	Soil application
	Vermiwash & Cow urine	2.50 ml/m^2 & 1.25 ml/m^2	Spray
Irrigation practices	Irrigation channels 30 cm apart		
Weed management	Hand weeding		

Organic plant protection practices	**Name of pest/disease**	**Recommended organic material used for control**	**Quantity/ m²area**
	All diseases & pests	Vermiwash (25 l/ha) & Cow urine (12.5 l/ha)	2.50 ml/m^2 1.25 ml/m^2
	All pests & diseases	Neem oil 5ml/lit (0.5%)	0.25 ml/m^2
Optimum age of nursery (days)	15-20 days old seedlings		

Field preparation: Incorporation of green manure (sunhemp) before one week of transplanting through rotavator, 2 pass puddler and leveller.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Cow urine	2.5% (12.5 l/ha)	seedling roots dip
	PSB & Azotobacter	500 g/ha500 g/ha	seedling roots dip
	Pseudomonas	500 g/ha	seedling roots dip
Spacing (row x plant) in cm	20cm x 20cm		
Number of seedlings/hill	2		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost	80 q	
	PSB & Azospirillum/ Azotobacter	500 g/ha & 500 g/ha	
	Pseudomonas	500 g	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Vermiwash	25.0 litres	15 days interval
	Cow urine	12.5 litres	15 days interval

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	03	During dry spell irrigation is required at tillering, panicle initiation	20 cm
Major weeds	Sanwa (*Echinochloa colonum, E. crusgalli),* Motha *(Cyprus rotundus, C. irria),* Dub grass *(Cynodon dactylon)*, Kancouwa (*Commelina benghalensis)*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Tillering (30 DAT)	Hand weeding/Rotary/cono-weeder (15-20 DAT)Hand weeding/ Rotary/cono-weeder (30-35 DAT)	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
All diseases	Pseudomonas (seedling roots dip)	500 g/ha	
	All diseases & some pests	Cow urine (15 days intervals)	2.5% (12.5 l/ha) spray
	All pests & some diseases	Neem oil 5ml/lit (0.5%)	2.5 l/ha spray

Yield

Parameters	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Mean**
Economic yield (kg/ha)	2500	2700	2800	2800	2900	3000	3100	2828

View of scented rice crop

Durum wheat

Particulars	*Rabi*
Crop	Durum wheat
Sowing/planting	IInd fortnight of November
Harvesting	Ist fortnight of April
Varieties	MPO 1106, Malwa shakti, HD 4672

Important features of suitable varieties

Varieties	MPO 1106	Malwa Shakti	HD 4672
Duration (days)	125	130	128
Average yield under organic condition (kg/ha)	34	41	37
Source (s) of availability	JNKVV, Jabalpur	JNKVV, Jabalpur	JNKVV, Jabalpur
Suitable regions/districts in the state	Jabalpur, Powarkheda, Sagar	Jabalpur, Powarkheda, Sagar	Jabalpur, Powarkheda, Sagar
Specific resistance / tolerance to disease	resistance to loose smut & rust	resistance to loose smut & rust	resistance to loose smut & rust
Specific tolerance to drought/waterlogging	tolerance to drought	tolerance to drought	tolerance to drought

Field preparation: 1pass disk for cutting the stubbles of previous crop, 1 pass cultivator followed by cross disk and 1 pass leveller & manual seed sowing/seed drill

Cultural practices

Seed rate (kg/ha)	100		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Cow urine	2.5% solution	Seed treatment

	PSB & Azotobactor	5 g/kg seeds5 g/kg seeds	Seed inoculation
	Pseudomonas	5 g/kg seeds	Seed inoculation
Spacing (row x plant) in cm	20cm or 22.5cm (row apart)		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost	80 q	
	PSB & Azotobactor	500 g	
	Pseudomonas	500 g	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Vermiwash	25.0 litres	15 days interval
	Cow urine	12.5 litres	15 days interval
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	6	CRI, Tillering, earhead initiation, booting, milking & dough stages	10 cm
Major weeds	*Cyperus rotundus, Melilotus spp., Chenopodium album, Convolvulus arvensis, Cynodon dactylon*		
Weed management	Critical stage of weeding	Recommended practice for organic condition	
	Root development	Hand hoeing (15-20 DAS)	
	Tillering	Hand weeding (30-35 DAS)	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	All diseases	Pseudomonas	500 g/ha (seed inoculation)
	All diseases & some pests	Cow urine	12.5 l/ha, spray (15 days intervals)
	All pests & some diseases	Neem oil 5ml/lit (0.5%)	2.5 l/ha spray(15 days intervals)

Yield

Parameters	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	2500	2800	3400	3800	4100	4150	4150	3557

View of Durum wheat crop

Harvested bundles of wheat crop

Chickpea

Particulars	***Rabi***
Crop	Chickpea
Sowing/planting	IInd fortnight, November
Harvesting	Ist fortnight, March
Variety	JG 322

Important features of suitable variety

Variety	**JG 322**
Duration (days)	123
Average yield under organic condition (kg/ha)	1400
Source (s) of availability	JNKVV, Jabalpur
Suitable regions/districts in the state	Jabalpur
Specific resistance / tolerance to disease	Resistant to wilt

Field preparation: 1pass disk for cutting the stubbles of previous crop, 1 pass cultivator followed by disk and 1 pass leveller & manual seed sowing/seed drill

Cultural practices

Seed rate (kg/ha)	80		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Cow urine	2.5% solution	Seed treatment
	PSB & Rhizobium sp	5 g/kg seeds & 5 g/kg seeds	Seed inoculation
	Trichoderma	5 g/kg seeds	Seed inoculation
Spacing (row x plant) in cm	30 or 45 cm (row apart)		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost	13 q	
	PSB & Rhizobium sp	2.5 kg & 2.5 kg	
	Trichoderma	2.5 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Vermiwash	25.0 litres	15 days interval
	Cow urine	12.5 litres	15 days interval
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Branching, pre flowering stages	10 cm
Major weeds	*Cyperus rotundus, Melilotus spp., Chenopodium album, Convolvulus arvensis, Cynodon dactylon*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Branching	Hand hoeing (15-20 DAS) Hand weeding (30-35 DAS)	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	All insects pests	Bird purchures	25 purchures/ha

	All diseases & some pests	Sowing of one row of coriander after 20 rows of chickpea	
	All diseases & some pests	Cow urine	12.5 l/ha, spray (15 days intervals)
	All pests & some diseases	Neem oil 5ml/lit (0.5%)	2.5 l/ha spray (15 days intervals)

Yield

Parameters	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Mean**
Economic yield (kg/ha)	800	950	1100	1225	1350	1375	1400	1171

Maize fodder

Particulars	**Summer**
Crop	Maize fodder
Sowing/planting	IInd fortnight, March
Harvesting	Ist fortnight, June
Variety	African tall

Important features of suitable variety

Variety	**African tall**
Duration (days)	73
Average yield under organic condition (kg/ha)	45000 (green fodder)
Source (s) of availability	JNKVV, Jabalpur
Suitable regions/districts in the state	Jabalpur

Field preparation: 1pass disk for cutting the stubbles of previous crop, 1 pass cultivator followed by disk and 1 pass leveller & manual seed sowing/seed drill

Cultural practices

Seed rate (kg/ha)	25		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Cow urine	2.5% solution	Seed treatment
	PSB & Azospirillum	5 g/kg & 5 g/kg	Seed inoculation
	Pseudomonas	5 g/kg	Seed inoculation
Spacing (row x plant) in cm	45 cm x 15 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost	60 q	
	PSB & Azospirillum	2.5 kg & 2.5 kg	
	Pseudomonas	2.5 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing /planting or stage of crop**
	Vermiwash	25.0 l/ha	15 days interval
	Cow urine	12.5 l/ha	15 days interval
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5	Late knee high, tasseling stages (10 days intervals)	10 cm
Major weeds	*Cyperus rotundus, Cynodon dactylon, Portchulaca olloresia*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25-30 DAS	Hand hoeing	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	All most diseases	Pseudomonas	5 g/kg seeds

	All most diseases & some pests	Cow urine	12.5 l/ha, spray (15 days intervals)
	All most pests & some diseases	Neem oil 5ml/lit (0.5%)	2.5 l/ha spray (15 days intervals)
Optimum stage of harvesting	Before 50% flowering		

Yield

Parameters	1st	2nd	3rd	4th	5th	6th	7th	Mean
Green fodder yield (kg/ha)	28200	29050	35060	38400	38800	38500	41100	35587


View of chickpea


View of maize (fodder)

Berseem (fodder + seeds)

Particulars	*Rabi*
Crop	Berseem (fodder+seed)
Sowing/planting	Ist Fortnight of November
Harvesting	IInd Fortnight of May
Varieties	JB-1, JB-2, JB-5

Important features of suitable varieties

Varieties	JB-1	JB-2	JB-5
Duration (days)	170	175	180
Average yield under organic condition (q/ha)	2.0 +590 (Seed +Fodder)	2.5 +670 (Seed +Fodder)	2.6 +725 (Seed +Fodder)
Source (s) of availability	JNKVV	JNKVV	JNKVV
Suitable regions/districts in the state	Jabalpur	Jabalpur	Jabalpur

Field preparation: Two pass of cultivation with the help of cultivator followed by cross disking and levelling.

Cultural practices

Seed rate (kg/ha)	25 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium culture	5 g/kg seed	Seed inoculation
	Trichderma viridi	5 g/kg seed	Seed inoculation
Spacing (row x plant) in cm	Broad casting		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost	1.33 t	
	PSB	2.5 to 3.0 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Cow urine	12.5 L/ha	15 day interval after sowing up to vegetative growth stage

	Vermiwash	25 L/ha	15 day interval after sowing up to vegetative growth stage
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	10-12 irrigation	After each cutting of green fodder, Branching, flowering & grain filling	10 cm
Major weeds	Amarbel (*Cuscuta spp.*), Sengi *(Melilotus alba/indica)*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	After last green fodder cutting	Hand weeding	

Yield

Economic yield	2.60 q/ha seed + 725 q/ha green fodder yield

View of berseem (fodder) crop

View of berseem (seeds) crop

Cutting of berseem (fodder)

Threshing of berseem (seeds)

Vegetable pea

Particulars	*Rabi*
Crop	Vegetable pea
Sowing/planting	Ist Fortnight of November
Harvesting	Ist Fortnight of Febuary
Varieties	Arkel, JM-1, JM-5 , PSM 3

Important features of suitable varieties

Parameters	Arkel	PSM 3	JM 1
Duration (days)	80	95	90
Average yield under organic condition (kg/ha)	80 q/ha Green pod	110 q/ha Green pod	102 q/ha Green pod
Source (s) of availability	JNKVV	JNKVV	JNKVV
Suitable regions/districts in the state	Jabalpur	Jabalpur	Jabalpur

Field preparation: 1pass disk for cutting the stubbles of previous crop, 1 pass cultivator followed by disk and 1 pass leveller & manual seed sowing/seed drill

Cultural practices

Seed rate (kg/ha)	80		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Cow urine	2.5% solution	Seed treatment
	PSB & Rhizobium sp	5 g/kg seeds & 5 g/kg seeds	Seed inoculation
	Trichoderma	5 g/kg seeds	Seed inoculation
Spacing (row x plant) in cm	30 or 45 cm (row apart)		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost	13 q	
	PSB & Rhizobium sp	2.5 kg & 2.5 kg	
	Trichoderma	2.5 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Vermiwash	25.0 litres	15 days interval

	Cow urine	12.5 litres	15 days interval
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Branching, pre flowering stages, pod formation	10 cm
Major weeds	*Cyperus rotundus, Melilotus spp., Chenopodium album, Convolvulus arvensis, Cynodon dactylon*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Branching	Hand hoeing (15-20 DAS) Hand weeding (30-35 DAS)	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	All diseases & some	Cow urine pests	12.5 l/ha, spray (15 days intervals)
	All pests & some diseases	Neem oil 5ml/lit (0.5%)	2.5 l/ha spray (15 days intervals)

Yield

Parameters	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (q/ha)	85	87	90	93	95	100	102	93

View of Vegetable pea crop

Organically grown vegetable pea

Sorghum fodder

Particulars	Summer
Crop	Sorghum fodder
Sowing/planting	Ist Fortnight of March
Harvesting	IInd Fortnight of May
Variety	MP Chari

Important features of suitable variety

Variety	MP chari
Duration (days)	74 days
Average yield under organic condition (kg/ha)	51000 (green fodder)
Source (s) of availability	JNKVV, Jabalpur
Suitable regions/districts in the state	Jabalpur

Field preparation: 1pass disk for cutting the stubbles of previous crop, 1 pass cultivator followed by disk and 1 pass leveller & manual seed sowing/seed drill

Cultural practices

Seed rate (kg/ha)	15		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Cow urine PSB Azospirillum Pseudomonas	2.5% solution 5 g/kg5 g/kg 5 g/kg	Seed treatment Seed inoculation Seed inoculation
Spacing (row x plant) in cm	45 cm x 10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost PSB & Azospirillum Pseudomonas	60 q 2.5 kg & 2.5 kg 2.5 kg	

Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Vermiwash	25.0 litres	15 days interval
	Cow urine	12.5 litres	15 days interval
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5	10 days intervals	10 cm
Major weeds	*Cyperus rotundus, Cynodon dactylon, Portchulaca olloresia*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25-30 DAS	Hand hoeing	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	All most diseases	Pseudomonas	500 g/ha (seed inoculation)
	All most diseases & some pests	Cow urine	12.5 l/ha, spray (15 days intervals)
	All most pests & some diseases	Neem oil 5ml/lit (0.5%)	2.5 l/ha spray (15 days intervals)

Yield

Parameters	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Mean**
Economic yield(kg/ha) (green fodder)	40000	41000	41960	44400	46000	49000	51000	44765

View of sorghum (Fodder) crop

Cutting of sorghum (Fodder)

Organic production system

Rice and berseem

MAHARASHTRA

Suggested cropping systems (based on testing under NPOF)

1. Rice-groundnut
2. Rice-*dolichos* bean
3. Rice-cucumber
4. Rice-red pumpkin

Details of crops in cropping systems

Rice

Particulars	*Kharif*
Crop	Rice
Sowing/planting	Nursery Sowing-Second fortnight of June Transplanting- Second fortnight of July
Harvesting	Second fortnight of October
Varieties	Karjat-3, Karjat-4, Karjat-7 and Palghar-1

Important features of suitable varieties

Varieties	Karjat-3	Karjat-4	Karjat-7	Palghar-1
Duration (days)	115-120	110-115	115-120	125-130
Average yield under organic condition (kg/ha)	3500 to 3700	3300 to 3500	3400 to 3600	3900 to 4100
Source (s) of availability	RARS, Karjat	RARS, Karjat	RARS, Karjat	RARS, Karjat
Suitable regions/districts in the state	Suitable for rainfed uplands as well as irrigated areas for *Kharif* and *Rabi* seasons in Maharashtra.	Suitable for rainfed uplands as well as irrigated areas for *Kharif* and *Rabi* seasons in *Konkan* region of Maharashtra.	Suitable for rainfed uplands and irrigated transplanted conditions in Maharashtra State.	*Konkan* region and Maharashtra state

Specific resistance/ tolerance to pest	Tolerant to stem borer	Moderately resistant to leaf folder	Resistant to leaf folder, BPH, WBPH and moderately resistant to stem borer	Moderately resistant to stem borer
Specific resistance/ tolerance to disease	Resistant to blast and moderately resistant to BLB and brown spots.		Moderately resistant to blast and BLB	Moderately resistant to blast
Specific tolerance to drought/water logging	Suitable for high rainfall zone	Suitable for high rainfall zone	Suitable for high rainfall zone	Suitable for high rainfall zone

Nursery raising practices

Area of nursery required for 1 ha	0.10 ha (1000m^2)		
Nursery raising method	Wet nursery /Mat nursery/Raised bed method etc.		
Bed size (length x breadth in m)	Length as per slope of the land (sloppy land less length, plane land more length) - Breadth- 1 m		
Seed sowing rate/m^2	45 to 50 g/m^2		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2 area**	**Method of application**
	Trichoderma	5g/kg of seed	Seed treatment
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/m^{2}area**	**Method of application**
	FYM	3 kg/m^2 area	Soil incorporation before nursery sowing
Irrigation practices	Rainfed		
Weed management	Mulching of *Glyricidia* green leaves and mannual hand weeding		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/m^2 area**
	Different insect pests	Application of neem formulation	1500 ppm@5 ml/lit of water for two times
Optimum age of nursery (days)	22 to 26 days		

Field preparation: Field is ploughed for solar heating in the month of May. Second ploughing and clod crushing is done before monsoon with wooden plough or tractor or power tiller drawn cultivator. Puddling is done by wooden plough or tractor or power tiller drawn puddler. Bullock drawn *Pankaj* puddler developed by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli should be used for better puddling. The field should be mannured with FYM and Neem cake @ 5 and 0.5 tonnes/ha, respectively before puddling. Similarly, 4.5 tonnes/ ha of *Glyricidia* green leaf and 4.2 tonnes/ha of rice straw be incorporated into puddled field prior to transplanting.

Cultural practices

Pre-sowing/planting treatment of seed/ seedlings	**Material**	**Recommended rate**	**Method of application**
	Phosphate solubilizing bacteria (PSB) and *Azospirillum*	PSB 2.5 kg + *Azospirillum* 2.5 kg + 100 lit of water/ha	Seedling root dip for 20 to 30 minutes in the slurry
Spacing (row x Plant) in cm	20x15cm		
Number of seedlings/hill	3-4 seedlings/hill		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	5000 kg before puddling	
	Neem cake	500 kg before puddling	
	Glyricidia Green leaves	4500 kg soil incorporation before transplanting	
	Rice straw	4200 kg soil incorporation before transplanting	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
1.	Cow urine	50 litres	Spraying at 30 and 60
2.	Vermiwash	50 litres	days after transplanting
Irrigation practices	Rainfed during *Kharif* and canal irrigation during *Rabi*		
Major weeds	*Echinochloa crusgalli* (Phakhad), *Echinochloa colonum* (Phakhad), *Cyperus iria* (Lavala), *Cyperus rotundus* (Lavala) and *Ischane globossa* (Dhur)		

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	20 Days after transplanting	Cono- weeder hoeing
	30 Days after transplanting (Tillering)	Cono- weeder hoeing and manual hand weeding
	60 Days after transplanting (Panicle initiation)	Manual hand weeding
Organic plant protection practices	**Name of the pest/ disease**	**Organic material recommended for control**
Insect pests	Stem borer	• Ploughing and collection of stubbles and their composting after harvesting of rice. • Use of tolerant and resistant varieties. • Crop rotation with ground nut, *Dolichos* bean, cucumber and red pumpkin. • Harvesting of rice close to the ground with *Vibhav* sickle developed by DBSKKV; Dapoli to kill the hibernating larvae. • Use of pheromone traps @20 Nos./ ha • Release of *Trichogramma* @ 50000/ ha for 4 times. • Collection of egg masses and their destruction. • Conservation and preservation of frogs in the field
	Case worm	• Timely transplanting • Intermittent draining out water from the field • Flooding the field followed by dragging a rope across the field and draining out the water from the field
	Brown Plant Hoppers (BPH), White Backed Plant Hoppers (WBPH) and Blue beetle	• Use of tolerant and resistant varieties. • Intermittent draining out water from the field

		• Judicious use of nitrogenous fertilizers. • Adoption of proper spacing (20x15cm) • Formation of alley ways for every three meters for penetration of sunlight and proper aeration
	Army worm	• Deep ploughing after harvesting of crop to expose the hibernating stages of pest. • Everyday inspection of the field during dry spell and at maturity. • Keeping the bunds clean and free of weed in the beginning of the season. • Digging the trench and flooding it with water for preventing migration of larvae from one field to another field. • Erection of bird perches. • Harvesting the crop immediately after it attains the maturity. • Conservation and preservation of frogs in the field.
	Leaf eating caterpillars	• Erection of bird perches.
Diseases	Blast and sheath rot	• Use of tolerant and resistant varieties. • Spraying of *Pseudomonas fluroscence* @ 8-10 g / lit of water [for 2-3 times] starting from maximum tillering to flowering stage.
	Bacterial leaf blight	• Use of tolerant and resistant varieties. • Intermittent draining out water from the field. • Judicious use of nitrogenous fertilizers. • Adoption of proper spacing (20x15cm)

Yield (kg/ha) of rice

Year	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14		Mean
							Grain	Straw	
Rice-Groundnut	1960	2873	3150	3543	3411	3842	3418	4032	3171
Rice-*Dolichos* bean	3148	2050	3940	2700	2780	3558	3324	3921	3071
Rice-Cucumber	2650	945	4175	3728	3565	3414	-		3080
Rice-Red pumpkin	3050	1260	4253	3676	3445	3236	-		3153

Rice under organic production system

Groundnut

Important features of suitable varieties

Varieties	SB-XI	Konkan Guarav	Konkan Trombay Tapora
Duration (days)	110-115	120-125	120-125
Average yield under organic condition (kg/ha)	1200 to 1500	1800 to 2000	1900 to 2100
Source (s) of availability	RARS, Karjat	RARS, Karjat	RARS, Karjat
Suitable regions/ districts in the state	Maharashtra state	Konkan region of Maharashtra	Konkan region of Maharashtra
Specific resistance/ tolerance to disease	Tolerant to *tikka* (leaf spot) and rust	Tolerant to *tikka* (leaf spot) and rust	Tolerant to *tikka* (leaf spot) and rust

Field preparation: Plough the field after harvest of *Kharif* rice. Criss-cross cultivation and clod crushing with peg tooth cultivator to bring the soil into good tilth.

Cultural practices

Seed rate (kg/ha)	SB XI- 95 kg kernels/ha, Konkan Guarav- 110 kg kernels /ha, Konkan Trombay Tapora- 125 kg kernels/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Trichoderma	5g/kg of seed	Seed treatment
	Rhizobium strain	25g/ kg of seed	Seed treatment
	PSB	25g/ kg of seed	Seed treatment
Spacing (row x Plant) in cm	30x15cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	1500 kg	
	Neem cake	160 kg	
	Vermicompost	560 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
1.	Cow urine	50 lit/ha	Spraying at 30 and

2.	Vermiwash	50 lit/ha	60 days after sowing
Irrigation practices	**Number of irrigation**	**Most critical stage of irrigation**	**Depth of irrigation (cm)**
	10 irrigations at an interval of 10-12 days	Branching, Flowering, Pegging, Pod formation and Pod filling	60 cm (6 cm/ irrigation)
Major weeds	*Physalis minima* (*Ranpopati*), *Portulaca oleracea* (*Motha ghol*), *Alternanthera sessilis* (*Reshimkata*), *Blumea lacera* (*Bhamrud*) and *Amaranthus viridis* (*Ranti math*)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 DAS	Dry land weeder	
	Flowering	Manual weeding at the time of earthing up.	
Organic plant protection practices	**Name of the pest/ disease**	**Organic material recommended for control**	**Quantity**
Insect pests	Aphids	• Application of neemicide	3ml/lit
	Tikka (leaf spot)	• Use of tolerant and resistant varieties.	
	Rust	• Use of tolerant and resistant varieties. • Judicious use of irrigation. • Timely harvesting.	
Optimum stage of harvesting	• General yellowing of crop. • Blackening of inside portion of shell. • Development of ridges on pod • Colour development of kernel as per varietal character.		

Yield

Year	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	Mean
Economic yield (kg/ha)	1671	3395	3648	2881	2584	2546	1876	2657

Dolichos bean

Particulars	*Rabi*
Crop	*Dolichos* bean
Sowing/planting	Sowing - Second fortnight of December
Harvesting	First fortnight of February to second fortnight of March
Variety	Konkan Bhushan

Important features of suitable variety

Variety	*Konkan Bhushan*
Duration (days)	100 days
Average yield under organic condition (kg/ha)	5000-5200 green pods kg/ha
Source (s) of availability	RARS, Karjat
Suitable regions/districts in the state	Maharashtra state
Specific resistance/tolerance to disease	Resistant to yellow mosaic virus
Special character	Dwarf, Does not require support

Field preparation: Plough the field after harvest of *Kharif* rice. Criss-cross cultivation and clod crushing with peg tooth cultivator to bring the soil into good tilth.

Cultural practices

Seed rate (kg/ha)	25kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Trichoderma	5g/kg of seed	Seed treatment
	Rhizobium strain	25g/ kg of seed	Seed treatment
	PSB	25g/ kg of seed	Seed treatment
Spacing (row x Plant) in cm	45 x 15 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	4000 kg	
	Neem cake	390 kg	

	Vermicompost	1330 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
1.	Cow urine	50 lit/ha	Spraying at 30 and
2.	Vermiwash	50 lit/ha	60 days after sowing
Irrigation practices	**Number of irrigation**	**Most critical stage of irrigation**	**Depth of irrigation (cm)**
	9 irrigations	Branching, Flowering and Pod formation	54 cm (6 cm/ irrigation)
Major weeds	*Physalis minima* (*Ranpopati*), *Portulaca oleracea* (*Motha ghol*), *Alternanthera sessilis* (*Reshimkata*), *Blumea lacera* (*Bhamrud*) and *Amaranthus viridis* (*Ranti math*)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25-40 DAS	Dry land weeder, One hand weeding	
Organic plant protection practices	**Name of the pest/ disease**	**Organic material recommended for control**	**Quantity**
Insect pests	Aphids	• Application of neemicide	3ml/lit
	Pod borer	• Application of neemicide	3ml/lit
Diseases	Powdery mildew	• Use of resistant and tolerant varieties.	
Optimum stage of harvesting	Picking for green pods from 60 to100 days after sowing		

Yield

Year	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**Mean**
Economic yield (kg/ha)	5024	2998	3017	1904	4949	5627	4974	4070

Cucumber

Particulars	*Rabi*
Crop	Cucumber
Sowing/planting	Sowing – First fortnight of January
Harvesting	First fortnight of March to first fortnight of April
Varieties	Hemangi and Sheetal

Important features of suitable varieties

Varieties	Hemangi	Sheetal
Duration (days)	100-110	95-105
Average yield under organic condition (kg/ha)	11500-12000	12000-12500
Source (s) of availability	Government/private agencies	DBSKKV, Dapoli
Suitable regions/districts in the state	Maharashtra state	Maharashtra state
Specific resistance/tolerance to disease	Tolerant to powdery mildew and downy mildew	

Field preparation: Ploughing the field after harvest of *Kharif* rice. Criss-cross cultivation and clod crushing with peg tooth cultivator to bring the soil into good tilth.

Cultural practices

Seed rate (kg/ha)	2.75 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Trichoderma	5g/kg of seed	Seed treatment
	PSB	25g/ kg of seed	Seed treatment
Spacing (row x plant) in cm	1.5 x 0.9 m		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	9000 kg	
	Neem cake	870 kg	
	Vermicompost	3000 kg	

Irrigation practices	**Number of irrigation**	**Most critical stage of irrigation**	**Depth of irrigation (cm)**
	12 irrigations	12 irrigations at an interval of 7-8 days	72 cm (6 cm/ irrigation)
Major weeds	*Physalis minima* (*Ranpopati*), *Portulaca oleracea* (*Motha ghol*), *Alternanthera sessilis* (*Reshimkata*), *Blumea lacera* (*Bhamrud*) and *Amaranthus viridis*(*Ranti math*)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-60 DAS	Hand weeding	
Organic plant protection practices	**Name of the pest/disease**	**Organic material recommended for control**	**Quantity (kg or liters/ha)**
Insect pests	Red pumpkin beetle	• Application of neemicide.	3ml/lit
	Fruit fly	• Erection of *Rakshak pheromone* trap designed by Dr. BSKKV, Dapoli	4 Nos. /ha
Diseases	Powdery and Downey mildew	• Growing tolerant and resistant varieties. • Crop rotation.	
Optimum stage of harvesting	60-100 DAS.		

Yield

Year	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha)	6044	8507	5509	5919	11357	12537	8312

Red pumpkin

Particulars	***Rabi***
Crop	Red pumpkin
Sowing/planting	Sowing – First fortnight of January
Harvesting	First fortnight of April
Variety	MPH-1

Important features of suitable variety

Variety	**MPH-1**
Duration (days)	95-100
Average yield under organic condition (kg/ha)	12500-13000 kg/ha
Source (s) of availability	RARS, Karjat
Suitable regions/districts in the state	Maharashtra state
Specific resistance/tolerance to disease	Tolerant to powdery mildew and downy mildew

Field preparation: Ploughing the field after harvest of *Kharif* rice. Criss-cross cultivation and clod crushing with peg tooth cultivator to bring the soil into good tilth.

Cultural practices

Seed rate (kg/ha)	6.5 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Trichoderma	5g/kg of seed	Seed treatment
	PSB	25g/ kg of seed	Seed treatment
Spacing (row x Plant) in cm	1.5 x 0.9 m		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	6670 kg	
	Neem cake	650 kg	
	Vermicompost	2230 kg	
Irrigation practices	**Number of irrigation**	**Most critical stage of irrigation**	**Depth of irrigation (cm)**
	10 irrigations	10 irrigations at an interval of 10 days	60 cm(6 cm/ irrigation)

Major weeds	*Physalis minima* (*Ranpopati*), *Portulaca oleracea* (*Motha ghol*), *Alternanthera sessilis* (*Reshimkata*), *Blumea lacera* (*Bhamrud*) and *Amaranthus viridis* (*Ranti math*)		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-60 DAS	Hand weeding	
Organic plant protection practices	**Name of the pest/ disease**	**Organic material recommended for control**	**Quantity (kg or liters/ha)**
Insect pests	Red pumpkin beetle	• Spraying of neemicide	3ml/lit
	Fruit fly	• Erection of *Rakshak pheromone* trap designed by DR. B.S.K.K.V. Dapoli.	4 Nos. / ha
Diseases	Powdery mildew and downy mildew	• Follow crop rotation. • Maintain field sanitation.	
Optimum stage of harvesting	• 90 – 100 DAS		

Yield

Year	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha)	17421	3369	11024	8450	12561	12726	10925

Maize under organic production system

Dolichos bean under organic production system

MEGHALAYA

Suggested cropping systems (based on testing under NPOF)

1. Rice-carrot (Raised beds in lowland)
2. Rice-tomato (Raised beds in lowland)
3. Maize+soybean-french bean (Upland)

Details of crops in cropping systems

Rice

Particulars	***Kharif***
Crop	Rice
Sowing/planting	July (transplanting)
Harvesting	November
Varieties	Shahsarang 1, Lampnah

Important features of suitable varieties

Varieties	**Shahsarang 1**	**Lampnah**
Duration (days)	140-145	140-150
Average yield under organic condition (kg/ha)	4050	3800
Source (s) of availability	ICAR-RC NEH, Umiam	ICAR-RC NEH, Umiam
Suitable regions/districts in the state	Ri-Bhoi district (800-1200 m above mean sea level)	Ri-Bhoi district (800-1200 m above mean sea level)
Specific resistance / tolerance to pest	Tolerant to stem borer	Tolerant to stem borer
Specific resistance / tolerance to disease	Tolerant to blast	Tolerant to blast
Specific tolerance to drought/waterlogging	Tolerant to iron toxicity	Tolerant to iron toxicity

Nursery raising practices

Area of nursery required for 1 ha	400 m^2		
Nursery raising method	Raised bed method		
Bed size (length X breadth in m)	10 m Length x 1.25 m breadth x 15 cm Height		
Seed sowing rate/m^2	50 g per m^2		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2 area**	**Method of application**
	Trichoderma harzianum	20 ml in 500 ml of water per acre	Seed treatment
	Neem cake	40 g per m^2	Soil application
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/m^2 area**	**Method of application**
	Farmyard manure (FYM)	1.5 kg/ m^2	Soil mixing @ 2:1 ratio
Irrigation practices	If continuous dry spell occurs for 4-5 days, then irrigation is advocated with rose can		
Weed management	Two hand weeding at 8 and 15 Days after sowing (DAS)		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/m^2 area**
	Leaf Hopper	Neem oil	3 ml/lt
Optimum age of nursery (days)	20 days		

Field preparation: The land is prepared thoroughly and well levelled with peripheral bunding. Puddling is done 2-3 times to make it weed free and water retentive. All weed biomass and crop residues of previous crop are incorporated with the soil during ploughing.

A nutrient dose of 80:60:40 kg/ha of N, P_2O_5 and K_2O is recommended. To supply these amount, about 15 t/ha of FYM is applied at around 15-20 days before transplanting. Also to obtained the required P nutrient dose, about 150 kg/ha of rock phosphate is applied in addition to the soil during transplanting. These nutrients are applied on N and P equivalent basis.

Cultural practices

Seed rate (kg/ha)	25-30 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azospirillium	100 ml in 10 litres of water	Root dip treatment (seedling roots are immersed in *Azospirillium* slurry for about 30 minutes before planting).
Spacing (row x plant) in cm	20 cm x 15 cm		
Number of seedlings/hill	2 seedlings		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	15 tonnes	
	Neem cake	100 kg	
	Rock phosphate	150 kg	
Top dressing of organic manures	**Source**	**Quantity**	**Days after sowing/ planting or stage of crop**
	Vermiwash	100 ml per litre of water	40-45 DAT (Days after transplanting)
	Panchagavya	3 litres per 100 litres of water	Flowering stage
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	An optimal irrigation practice is followed by managing rainfall. Continuous submergence of 2-5 cm is maintained during transplanting to maturity. However, water is drained out during tillering stage to facilitate better tillering. Water is drained permanently during physiological maturity. If dry spell occurs continuously for 10-12 days, life saving irrigation is recommended.		
Major weeds	**Scientific name**	**Common name**	
	Spilanthus Acmella	Toothache plant	

	Alternanthera philoxeroides	Alligator weed	
	Rotala indica	Indian toothcup	
	Echinocloa crusgalli	Barnyard grass	
	Cyperus rotundus	Nutgrass	
	Ageratum houstonianum	Floss flower	
	Polygonum hydropiper	Water pepper	
	Cuphea hyssopifolia	False heather	
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25-45 DAT	Two hand weeding and one Cono-weeding is recommended to manage weeds. First hand weeding is done at 20 DAT and second at 55 DAT. One cono weeding with the use of cono weeder is carried out at 35 DAT	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Common insect-pests and diseases of rice	Pestoneem Derisom Neem cake (Soil application)	3 ml/lt 2 ml/lt 100 kg/ha

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	3660	3900	3800	3980	4170	4390	4470	4052

Carrot

Important features of suitable variety

Variety	**New kuroda**
Duration (days)	95-100
Average yield under organic condition (kg/ha)	12000
Source (s) of availability	Market/Tokiis or Tokita company
Suitable regions/districts in the state	Ri-Bhoi, Mid altitude of Meghalaya (800-1200 m ASL)
Specific resistance / tolerance to pest	No major insect-pest found
Specific resistance / tolerance to disease	No major diseases found
Specific tolerance to drought/waterlogging	Susceptible to water logging condition

Field preparation: After the harvest of rice, the land is configured into temporary raised bed of 30 cm height, 3m width and 7 m length to facilitate drainage for the growing of carrot crop. The soil is prepared by one deep ploughing with spade followed by harrowing. At least 1/3rd rice residues is retained and incorporated into the soil during ploughing. Planking is done to make the soil clod free. As the seeds of carrot are very small, the field is to be prepared up to a fine tilth. After the sowing of seeds in line, a mixture of soil and FYM (2:1) is spread over the seeds for covering.

Cultural practices

Seed rate (kg/ha)	4-5 kg/ha		
Spacing (row x plant) in cm	30 cm x 3-4 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Phosphate solubilizing bacteria (PSB)	1.5 kg/ha	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Vermiwash	50 litres	Vegetative and flowering stage

Irrigation practices for irrigation	**Number of irrigations** **Depth of irrigation (cm)**	**Most critical stages**
	In Meghalaya, after harvesting of rice, there is enough moisture in valley land due to seepage from surrounding hillocks, carrot grow normally under residual soil moisture. However, if required, life saving irrigation is given during dry spell.	

Major weeds	**Scientific name**	**Common name**
	Commelina benghalensis	Day flower
	Galinsoga parviflora	Gallant soldier
	Oxalis corniculata	Sleeping beauty
	Chenopodium album	Lamb's quarters
	Drymaria cordata	Tropical chick weed

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	30-35 DAS	One hand weeding and hoeing along with earthing up at about 30-35 DAS is carried out to suppress weed growth. Thinning is also being done at the time of weeding.

Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Carrot fly, Bacterial blight, Powdery mildew	Pestoneem Derisom	3 ml/lt 2ml/lt

Optimum stage of harvesting	The root attain marketable stage when their diameter of tuber is 2-4 cm at the upper end

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Mean**
Economic yield (kg/ha)	10780	14060	11950	11860	11970	13800	12750	12452

Tomato

Particulars	Summer
Crop	Tomato
Sowing/planting	February
Harvesting	May
Varieties	Rocky, Avinash-2, Mega Tomato-3

Important features of suitable varieties

Varieties	Rocky	Avinash 2	Mega Tomato-3
Duration (days)	100-105	105-110	100-110
Average yield under organic condition (kg/ha)	20425	21309	23000
Source (s) of availability	Market, Syngenta Co.	Market, Syngenta Co.	ICAR-RC NEH, Umiam
Suitable regions/districts in the state	Ri-Bhoi	Ri-Bhoi	

Nursery raising practices

Area of nursery required for 1 ha	200 m^2		
Nursery raising method	Raised bed method		
Bed size (length x breadth in m)	10 m Length x 1 m breadth x 15 cm Height*Rows are made at 10 cm distance along the width of bed with the help of bamboo stick. Vermicompost is applied on prepared beds and seeds are sown in line followed by covering with vermicompost or sand. Nursery bed is covered with dry grass or paddy straw or polythene for 3-5 days to induce early germination of seeds. The covering is removed immediately as soon as sprouts come out.		
Seed sowing rate/m^2	5 g/m^2		
Source and optimum quantity of organic manures/other	**Materials**	**Quantity/ m^2area**	**Method of application**
nutrient source/m^2 of nursery	Vermicompost	4 kg/ m^2	Mixing with soil

Irrigation practices	After sowing of seeds, the nursery beds are irrigated with water and thereafter, light irrigation with rose can is given everyday morning and evening.		
Weed management	Two hand weeding is needed to suppress weed growth		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/ m^2 area**
	No pesticides applied in nursery		
Optimum age of nursery (days)	25-30 days		

Field preparation: The land is configured into temporary raised bed of 30 cm height, 2m width and 8 m length after the harvest of rice, to facilitate the growing of Tomato crop. A well pulverized soil is obtained by ploughing the raised beds 2 times followed by harrowing. 30 % of rice stubbles is retained and incorporated into the soil during ploughing.

Since the soil of this region is acidic in nature, lime application is recommended @ 500 kg/ ha during the final bed preparation. FYM @ 20 t/ha (on N equivalent basis) is applied in pits of 50cm x 50cm spacing at the time of transplanting. To supplement the requirement of Phosphorus, Rock phosphate @ 200 kg/ha (on P equivalent basis) is applied in the pits during transplanting time. Neem cake @ 150 kg/ha is also applied in the pits before transplanting to check soil borne diseases

Cultural practices

Seed rate (kg/ha)	400 g/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Trichoderma harzianum	100 ml in 10 Litres of water	Root dip treatment (seedling roots are immersed in *Trichoderma* slurry for about 30 minutes before planting).
Spacing (row x plant) in cm	50 cm x 50 cm		
Number of seedlings/hill	1 seedling per hill		

Basal application of organic manures	**Source**	**Quantity/ha**
	FYM	20 tonnes
	Rock phosphate	200 kg
	Neem cake	150 kg

Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Panchagavya	3 litres per 100 litres of water	25-30 DAT

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**
	During dry year, 2-3 life irrigation is required.	Vegetative, Flowering and Fruit formation stage.

Major weeds	**Scientific name**	**Common name**
	Drymaria cordata	Tropical chick weed
	Galinsoga parviflora	Gallant soldier
	Oxalis corniculata	Sleeping beauty
	Commelina benghalensis	Day flower

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	Vegetative stage	Hand hoeing

Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Leaf miner, Fruit borer, White fly	Lantana leaf extract (10%)	100 ml in 1 litre of water
		Pestoneem	2.5 ml/lt
	Nematodes and Late blight	Derisom	2 ml/lt

Optimum stage of harvesting	Pink to light red colour fruits

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	29800	25000	24500	26200	19300	21300	20600	23814

Mixing of FYM and soil for nursery bed preparation (2:1)

Preparing tomato pits for transplanting

Applying rock phosphate in tomato pit

Tomato grown under organic in raised beds

Fruiting of tomato

Harvested tomato from organic plot

Maize+soybean (2:2 ratio)

Particulars	Summer
Crop	Maize+soybean
Sowing /planting	April-May
Harvesting	July-August
Varieties	Maize-DA-61-A, RCM-1-3, Soybean- JS-80-21

Important features of suitable varieties

Varieties	Maize		Soyabean
	DA-61-A	**RCM-1-1**	**JS-80-21**
Duration (days)	110-115	110-120	145-150
Average yield under organic condition (kg/ha)	4500-4900	4400-4800	1800-2100
Source (s) of availability	ICAR-RC NEH, Umiam	ICAR-RC NEH, Umiam	ICAR-RC NEH, Umiam
Suitable regions/districts in the state	Ri-Bhoi district, Dimapur (Nagaland), Garo Hills district	Ri-Bhoi district, Dimapur (Nagaland), Garo Hills district	Ri-Bhoi district, Dimapur (Nagaland), Garo Hills district
Specific resistance/tolerance to pest	Tolerant to Stem borer		

Field preparation: Land is ploughed 2 times at a depth of 20-25 cm followed by 2 harrowing to obtain fine tilth. A properly levelled and uniformly graded field is required for good water management. Good drainage should be provided in maize field, because stagnation of water in the field is harmful to the crop. Lime @ 500kg/ha is mixed with the soil at final land preparation to improve soil health. It is to be noted that liming is carried out only once in 3 years.

Maize is intercropped with soybean at 2:2 ratio (soybean-maize-maize-soybean-soybean-maize i.e. 30-50-50-30-30-50 cm). To obtain the mentioned ratio, two lines of maize are grown at a distance of 50 cm apart alternated by two lines of soybean at a distance of 30 cm apart. The Farmyard manure (FYM) @ 15 t/ha (on N equivalent basis), Rock phosphate @ of 150 kg/ha (on P_2O_5 equivalent basis) and neem cake @ 100 kg/ha are applied in the opened furrows and mixed well with the soil at the time of sowing. Seeds are placed in these furrow lines, at a distance of 25 cm for maize and 10 cm for soybean and covered with soil.

When the soybean crop reaches 40-45 days, leaving about 30 cm standing stalks upper portion of the soybean plant is detopped and placed besides the maize plant for better plant nutrition. The soybean biomass is then used for green manuring. Earthing up of maize is done after the detopping of soybean for proper crop stand of maize and also for better incorporation of soybean biomass into the soil.

Cultural practices

Seed rate (kg/ha)	20-25 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Trichoderma viride	5 g/kg of seed	Seed treatment
Spacing (row x plant) in cm	50 cm x 25 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	15 tonnes	
	Neem cake	150 kg	
	Rock phosphate	200 kg	
Top dressing of organic manures	**Source**	**Quantity**	**Days after sowing/ planting or stage of crop**
	Vermiwash	100 ml per litre of water	30 DAS
	Panchagavya	3 litres per 100 litres of water	Tasseling (60-65 DAS)
Irrigation practices	**Number of irrigations**		**Most critical stages for irrigation**
	Maize is grown under rainfed condition in Meghalaya. However, if prolong dry spell for 15-20 days occurs, life saving irrigation may be given at critical stages of the crop.		Knee high stage and Tasseling stage

Major weeds	**Scientific name**	**Common name**
	Alternanthera philoxeroides	Alligator weed
	Drymaria cordata	Tropical chick weed
	Commelina benghalensis	Day flower
	Ageratum conyzoides	Goat weed

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	Knee high stage and Tasseling stage	Two hand weeding is recommended to manage weeds. First hand weeding is done at 25 DAS and second at 50 DAS.

Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Stem borer	Pestoneem	3 ml/lt
	Cob borer	Derisom	2.5 ml/lt
	Cut worms	Lantana leaf extract	10 %
	Leaf blight		
	Brown spot		

Optimum stage of harvesting	The cob is harvested when the plant has become straw coloured (light brown) and the grain hard, some of the cobs will droop downwards.

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	4500	4900	4700	4800	5100	4880	5020	4850

Maize+soyabean (2:2 ratio)

Maize at physiological maturity stage

Maize cob ready for harvest

French bean

Important features of suitable varieties of French bean

Varieties	Naga local	RCM FB-18
Duration (days)	90-95	85-90
Average yield under organic condition (kg/ha)	8600	8000
Source (s) of availability	ICAR-RC Umiam	ICAR-RC Umiam
Suitable regions/districts in the state	Ri-Bhoi, Mid altitude of Meghalaya (800-1200 m ASL)	Ri-Bhoi, Mid altitude of Meghalaya (800-1200 m ASL)

Field preparation: After the harvest of maize, maize stubbles are cut at 1 m height for recycling of residues. Two furrow lines are made in between each row of maize for sowing of French bean seed. FYM, Rock phosphate, Neem cake @ 15 t/ha, 150 kg/ha and 100 kg/ha (on N and P_2O_5 equivalent basis) respectively are applied in the furrow lines and mixed with soil. Seeds are placed at a distance of 15 cm plant to plant and the seeds are covered with soil immediately after sowing.

Cultural practices

Seed rate (kg/ha)	25-30 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Trichoderma viride	5 g/kg of seed	Seed treatment
Spacing (row X plant) in cm	25 cm x 15 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	15 tonnes	
	Neem cake	150 kg	
	Rock phosphate	200 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing / planting or stage of crop**
	Panchagavya	25 litre	20-25 DAS

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	The crop is grown under rainfed condition. However, one life saving irrigation is given during dry spell		

Major weeds	**Scientific name**	**Common name**
	Drymaria cordata	Tropical chick weed
	Commelina benghalensis	Day flower
	Galinsoga parviflora	Gallant soldier
	Oxalis corniculata	Sleeping beauty
	Chenopodium album	Lamb's quarters

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	30-35 DAS	One hand weeding and hoeing along with earthing up at about 30-35 DAS is carried out to suppress weed growth

Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Anthracnose Rhizoctonia blight	Pestoneem	2.5 ml/lt
	Blister beetle Mites	Derisom	2ml/lt

Optimum stage of harvesting	Tender pods become ready for harvest from 55-60 DAS

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	7400	7900	8420	9030	8900	9210	9580	8634

French bean (Naga local)

French bean (RCM FB-18)

French bean pod ready for harvest

Details of specific practices/products used/recommended

Name of the input	Source and preparation	Time, rate and purpose of application
Panchagavya	It is a cow excreta based indigenous nutrient solution. Panchagavya consists of nine products viz. cow dung, cow urine, milk, curd, jaggery, ghee, banana, Tender coconut and water. When suitably mixed and used, these have miraculous effects. The preparation steps of panchagavya is as follows; 1. 7 kg. cow dung and 1 kg. cow ghee is mixed thoroughly both in morning and evening hours and is kept for 3 days. 2. After 3 days, 10 lt. cow urine and 10 lt. water is added, mixed and kept for 15 days with regular mixing both in morning and evening hours. 3. After 15 days the following ingredients are added and mixed • Cow milk - 3 liters • Cow curd - 2 liters • Tender coconut water - 3 liters • Jaggery - 3 kg • Well ripened banana – 12 nos. Panchagavya is ready after 30 days.	3% solution was found to be most effective compared to the higher and lower concentrations investigated. 3 litres of Panchagavya to every 100 litres of water is ideal for all crops.
Lantana leaf extract 10%	Leaves of *Lantana camara* were collected from the nearby area of the farm and 10% aqueous leaf extract is prepared firstly by grinding the leaves and then soaking 100g of grinded leaves in 200 ml. distilled water for 24 hours at a room temperature of 30°C. The aqueous extract was obtained by filtering the mixture (leaf and water) through a Whatman No .42 filter paper and diluted with distilled water to prepare 10% concentration.	The extract is diluted with water @ 10% before spraying. This foliar spray act as insect-pest repellent. It can be sprayed 3-4 times during the crop duration according to pest infestation.

Derisom	It is a bio-pesticide based on botanical extract of *Derris indica*.	It is applied as foliar spray @ 0.2% or 2 ml/lt. of water. It can be sprayed 2-3 times during the crop duration according to pest infestation. Derisom has Karanjin as active principle and acts as antifeedant and also acts on central nervous system of the Mites and Insect pests. Derisom works as Acaricide (Miticide) and Insecticide.
Pestoneem	Neem biopesticide is made from cold pressed neem kernels and its active azadirachtin 1500ppm is used as a general insecticide, fungicide and for coating urea for slow release	It is a bio-based pest controller containing 0.5% Azadirachtin and other vital bio-energizers. Application of pestoneem increase resistance to infestation of pest and disease.


Collection of FYM from pit


Application of rock phosphate before sowing of rice

Vermiwash drum


Maize+soybean intercropping system


Maize varietal screening under organic farming


Organic farming in raised and sunken beds

Glimpses of Practices


Opening furrow


Applying rock phosphate in furrow


Placing of seeds in furrow


FYM


Vermicompost


Placing of FYM in furrow

Few suitable organic pesticides used in all three cropping systems

Vermiwash


Derisom

Tricoderma harzanium


Pestoneem

PUNJAB

Suggested cropping systems (based on testing under NPOF)

1. Maize-potato-summer greengram
2. Turmeric-onion
3. Basmati rice-wheat-green manure
4. Maize-durum wheat-cowpea (fodder)
5. Maize-berseem-bajra (fodder)
6. Maize-berseem-maize+cowpea (fodder)

Details of crops in cropping systems

Maize

Particulars	***Kharif***
Crop	Maize
Sowing/planting	2nd fortnight of June
Harvesting	1st fortnight of Oct
Variety suitable for organic farming	Prabhat

Important features of suitable variety

Variety	**Prabhat**
Duration (days)	95
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab
Specific tolerance to drought/water logging	Logging resistance

Field preparation: Four ploughing (Disc harrow/Cultivator) and planking

Cultural practices

Seed rate (kg/ha)	20		
Spacing (row x plant) in cm	60 x 20		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM (1% N)	4.25 tonnes	
	Vermicompost (1.5% N)	2.75 tonnes	
	Non edible cake (2.5% N)	1.65 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5	Tasselling	7.5
Major weeds	*Commelina benghalensis, Trianthema portulacastrum & Brachiaria reptans*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20-40 DAS	Hand weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Stem borer	Tricho cards	40 cards/acre at 10-15 DAS

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	5190	4540	4200	4643

Potato

Important features of suitable variety

Variety	Kufri Chandramukhi
Duration (days)	80-90
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab

Field preparation: Ploughing (mould board/ disc plough) and planking

Cultural practices

Seed rate (kg/ha)	3750		
Spacing (row x plant) in cm	60 x 20		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost	4.25 tonnes	
	(1.5% N)		
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	7	Tuber formation	7.5
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-45 DAS	Hand weeding	

Yield

Year	1st	2nd	3rd	4th	5th	Mean
Economic yield (kg/ha)	15600	14850	15280	20440	17200	16674

Summer greengram

Important features of suitable variety

Variety	**SML 668**
Duration (days)	60
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab
Specific resistance / tolerance to pest	Thrips
Specific resistance / tolerance to disease	Moongbean yellow mosaic virus

Field preparation: Two ploughing and planking (Disc harrow/Cultivator)

Cultural practices

Seed rate (kg/ha)	37.5			
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**	
	Rhizobium	0.5	Mixing with seed	
Spacing (row x plant) in cm	22.5 x 7			
Basal application of organic manures	**Source**	**Quantity/ha**	**Source**	**Quantity/ha**
	FYM (1% N)	1.25 tonnes or	FYM (1% N)	0.75 t/ha
			VC (1.5% N)	0.25 t/ha
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**	
	4	Flowering	7.5	
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**		
	30-40 DAS	Hand weeding		

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Mean**
Economic yield (kg/ha)	900	1580	1330	1160	1240	1242

Turmeric

Particulars	***Kharif***
Crop	Turmeric
Fortnight of sowing/planting	1st fortnight of May
Fortnight of harvesting	2nd fortnight of Dec
Varieties suitable for organic farming	Pb Haldi 1

Important features of suitable variety

Variety	**Pb Haldi 1**
Duration (days)	215
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab

Field preparation: Two plouging (Disc harrow/cultivatior) and planking

Cultural practices

Seed rate (kg/ha)	2000			
Spacing (row x plant) in cm	30 x 20			
Basal application of organic manures	**Source**	**Quantity/ha**	**Source**	**Quantity/ha**
	FYM (1% N)	15 tonnes or	FYM (1% N) VC (1.5% N)	10 t/ha 3.25 t/ha
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**	
	15	Rhizome formation	7.5	
Major weeds	*Eleusine indica*, *Trianthema portulacastrum*, *cyperus rotundus*, *Digitaria ciliaris* (Takri gha)			
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**		
	30-45 DAS	Apply 10 t/ha rice straw mulch and if needed give one hoeing at 3 months of sowing the crop or give 3 hand weedings at 1, 2 and 3 months of sowing the crop.		
Optimum stage of harvesting	Complete yellowing and drying of plant			

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Mean**
Economic yield (kg/ha)	62850	19750	25260	28650	27910	32884

Onion

Important features of suitable variety

Variety	**Pb Naroa**
Duration (days)	145
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab
Specific resistance / tolerance to pest	Thrips,Heliothis
Specific resistance / tolerance to disease	Purple Blotch

Nursery raising practices

Area of nursery required for 1 ha	62.5 m^2		
Nursery raising method	raised bed method		
Bed size (length x breadth in m)	2.5m x 1m		
Seed sowing rate/m^2	1 g		
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^2 area**	**Method of application**
	FYM (1% N)	5 kg	Broadcast
Weed management	Hand weeding		
Optimum age of nursery (days)	30 DAS		

Field preparation: One ploughing followed by planking

Cultural practices

Seed rate (kg/ha)	10
Spacing (row x plant) in cm	15 x 7.5

Number of seedlings/hill	1-2				
Basal application of organic manures	**Source**	**Quantity/ha**		**Source**	**Quantity/ha**
	FYM (1% N)	10 tonnes	or	FYM (1% N)	6.75 t/ha
				VC (1.5% N)	2.25 t/ha
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**		
	12	Bulb formation	7.5		
Major weeds	*Phalaris minor, Medicago denticulate*, *Anagalis arvensis, Lepidium sativa*				
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**			
	30-45 DAT	Hand weeding			

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Mean**
Economic yield (kg/ha)	13750	12650	16930	18050	14890	15254

Onion under organic management

View of experimental plot of onion under organic management

Basmati rice

Particulars	***Kharif***
Crop	Basmati Rice
Fortnight of nursery sowing/planting	1st fortnight of June/1st fortnight of July
Fortnight of harvesting	1st fortnight of Nov
Varieties suitable for organic	Punjab Basmati 2

Important features of suitable variety

Variety	**Punjab Basmati 2**
Duration (days)	140
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab

Nursery raising practices

Area of nursery required for 1 ha	500 m^2		
Nursery raising method	Flat bed sowing		
Bed size (length x breadth in m)	10 m x 2 m plot size		
Seed sowing rate/m^2	40 g		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2 area**	**Method of application**
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials** FYM (1% N)	**Quantity/ m^2 area** 12 kg	**Method of application** Broadcasting
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/ m^2area**
	Stem borer	Tricho cards	40 cards/acre at 5-6 times
Optimum age of nursery (days)	30-35		

Field preparation: Two ploughing (Disc harrow/Cultivator) and planking

Cultural practices

Seed rate (kg/ha)	20		
Spacing (row x plant) in cm	20 x 15 cm		
Number of seedlings/hill	1-2		
Basal application of manure	**Source**		
	Green manure		
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	15	Panicle initiation	7.5
Major weeds	*Cyperus spp, Eleusine indica, Caesulia axillaris, Echinochloa crusgalli, Ischaemum rugosum, Sphenoclea zeylanica*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-40 DAT	Hand weeding	

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	2990	3120	2420	2843


Basmati rice transplanting under organic management


Basmati rice at vegetative stage under organic management

Wheat

Important features of suitable variety

Variety	**PBW 621**
Duration (days)	158
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab
Specific resistance / tolerance to disease	Brown rust,Yellow rust

Field preparation: Three ploughing fallowed by planking

Cultural practices

Seed rate (kg/ha)	100		
Spacing (row x plant) in cm	20 cm row spacing		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM (1% N)	4.25 tonnes	
	VC (1.5% N)	2.75 tonnes	
	NEC (2.5% N)	1.65 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5	CRI	7.5
Major weeds	*Chenopodium album, Phalaris minor, Convolvulus arvensis, Rumex dentatus, Malva neglecta*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-45 DAS	Hand weeding	

Yield

Year	**1st**	**2nd**	**3rd**	**Mean**
Economic yield (kg/ha)	3350	4440	4940	4243

Sunhemp (Green manure *summer*)

Important features of suitable variety

Variety	**PAU 1691**
Duration (days)	45-60
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab

Field preparation: Ploughing and planking

Cultural practices

Seed rate (kg/ha)	50		
Spacing (row x plant) in cm	22.5 cm row spacing		
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	-	7.5

Sun hemp seed production under organic management

Sun hemp for green manuring under organic management

Durum wheat

Important features of suitable variety

Variety	**PDW 291**
Duration (days)	155
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab
Specific resistance / tolerance to disease	Yellow rust, Brown rust, Karnal Bunt & Loose smut

Field preparation: Two ploughings followed by planking

Cultural practices

Seed rate (kg/ha)	100		
Spacing (row x plant) in cm	20 cm row spacing		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM(1% N)	4.25 tonnes	
	VC(1.5% N)	2.75 tonnes	
	NEC(2.5% N)	1.65 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5	CRI	7.5
Major weeds	*Chenopodium album, Phalaris minor, Convolvulus arvensis, Rumex dentatus, Malva neglecta*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-45 DAS	Hand weeding	

Yield

Year	**1st**	**2nd**	**3rd**	**Mean**
Economic yield (kg/ha)	3570	5420	4870	4620

Cowpea fodder

Field preparation: One ploughing followed by planking

Cultural practices

Seed rate (kg/ha)	50		
Spacing (row x plant) in cm	30 cm row spacing		
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	4	-	7.5
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-40 DAS	Hand weeding	

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha) green fodder	24360	37270	31750	31127

Maize + cowpea (fodder)

Organic fodder production experimental block at PAU, Ludhiana

Maize

Particulars	***Kharif***
Crop	Maize
Sowing/planting	1st fortnight of Aug
Harvesting	2nd fortnight of Oct
Variety	J 1006

Important features of suitable variety

Variety	**J 1006**
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab
Specific resistance / tolerance to disease	Maydis leaf blight, Brown Stripe downy mildew

Field preparation: Two ploughing (Disc harrow/Cultivator) and planking

Cultural practices

Seed rate (kg/ha)	75	
Spacing (row x plant) in cm	30 cm row spacing	
Basal application of organic manures	**Source**	**Quantity/ha**
	FYM (1% N)	8.75 tonnes
Irrigation practices	**Number of irrigations**	**Depth of irrigation (cm)**
	8	7.5
Major weeds	*Commelina benghalensis, Trianthema portulacastrum& Brachiaria reptans*	
Optimum stage of harvesting	50-60 DAS	

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Mean**
Green fodder yield (kg/ha)	16700	9620	12040	14760	14610	13330	24520	38900	18060

Berseem

Important features of suitable variety

Variety	**BL 10**
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab

Field preparation: Three ploughing and Planking

Cultural practices

Seed rate (kg/ha)	20		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium	0.5	Mixing with seed
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM (1%N)	2.5 tonnes	
Irrigation practices	**Number of irrigations**	**Depth of irrigation (cm)**	
	6	7.5	
Major weeds	*Poa annua, Trianthema potulacastrum*		

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Mean**
Economic yield (kg/ha)	78000	57370	67970	62760	62750	76810	61850	61100	66076

Bajra

Important features of suitable variety

Variety	PCB 164
Duration (days)	50-60
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab
Specific resistance / tolerance to disease	Downy mildew

Field preparation: 2-3 ploughing

Cultural practices

Seed rate (kg/ha)	20	
Spacing (row x plant) in cm	22 cm row spacing	
Basal application of organic manures	**Source**	**Quantity/ha**
	FYM (1% N)	5 tonnes
Irrigation practices	**Number of irrigations**	**Depth of irrigation (cm)**
	8	7.5
Major weeds	*Commelina benghalensis, Trianthema portulacastrum& Brachiaria reptans*	
Optimum stage of harvesting	40-55 DAS	

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	8th	Mean
Economic yield (kg/ha) (Green fodder)	46500	75140	53470	31990	34130	26810	24270	34600	40864

Maize + Cowpea *summer*

Important features of suitable varieties

Varieties	**J 1006, Cowpea 88**
Source (s) of availability	PAU
Suitable regions/districts in the state	Punjab

Field preparation: Two ploughing and planking

Cultural practices

Seed rate (kg/ha)	37.5+37.5	
Spacing (row x plant) in cm	30 cm row spacing	
Basal application of organic manures	**Source**	**Quantity/ha**
	FYM (1% N)	8.75 tonnes
Irrigation practices	**Number of irrigations**	**Depth of irrigation (cm)**
	8	7.5
Major weeds	*Trianthema potulacastrum, Digitaria sanguinalis*	
Optimum stage of harvesting	50-60 DAS	

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Mean**
Green fodder yield (kg/ha)	43200	40610	33020	34740	29330	30000	29470	34600	34371

Berseem under different management systems

Organic Summer Greengram

Chemical basmati rice

Organic basmati rice

Green manure (Sunnhemp)

Chemical (L) and organic (R) Turmeric

RAJASTHAN

Suggested cropping systems (based on testing at MPUAT & NPOF)

1. Blackgram-fenugreek
2. Clusterbean-chickpea
3. Sesame-cumin
4. Groundnut-mustard
5. Groundnut-wheat
6. Castor-greengram
7. Maize-wheat (durum)
8. Soybean-coriander

Black gram

Particulars	***Kharif***
Crop	Black gram
Sowing/planting	First Fortnight of July
Harvesting	Second Fortnight of October
Variety	PU-31

Important features of suitable variety

Variety	**PU-31**
Duration (days)	70-80 days
Average yield under organic condition (kg/ha)	1000-1200 kg/ha

Source (s) of availability	RSSC,Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara, Chittorgarh, Rajsamand, Banswara

Field preparation:

1. Deep summer ploughing to hamper the population of soil born pest and disease pathogen.
2. Deep ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	15-20 Kg/ha.		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium and Phosphorous Solubilizing Bacteria (PSB culture)	500g each	To prepare make a solution by adding 250 g of jaggery in one litre of hot water. After cooling add 500 g/ha Rhizobium and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Trichoderma @ 8 g/kg seeds	160 g/ha	Seed treatment
	Neem cake	200 Kg/ha	Soil treatment before sowing

Spacing (row x plant) in cm	30x10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	4 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	BD-500	75 g/40L water	20 DAS in evening before sowing
	BD-501	2.5 g/40L water	20 DAS in morning 15 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Flowering & pod formation	30 cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nutsedge	*Cyperus* spp.
	Bokna	Day flower	*Commelina benghalensis*
	Salara	White cock's comb	*Celosia arvensis*
	Kundra	Digera	*Digera arvensis*
	Sanwa ghas	Barnyard grass	*Echinochloa crusgalli*
	Kodon	Goosegrass	*Eleusine indica*
	Sathi	Horse purslane	*Trianthema portulacstrum*
	Doob ghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia* spp.

Weed management	Critical stage of weeding	Recommended practice for organic condition
	Early stage of crop growth, crop should be weed free up to 30 DAS	Weed control in organic systems, especially in black gram production, relies heavily on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at 45 DAS should be given. Smother cropping, intercropping and mulching reduce weed density in the field.

Organic plant protection practices	Name of pest/disease	Organic material recommended for control	Quantity
	Aphids & white fly	Spray of neem oil (2%)	20 ml/L
	Pod Borer	Two sprays of neem oil (2%). First on appearance of pest and repeat after 10 days interval.	20 ml/L Water
	Yellow Vein Mosaic Virus	Spray of neem oil (2%) at 25 DAS.	20 ml/L Water
	Leaf spots	BD-501(2.5 g/40 L Water). First on appearance of pest and repeat after 10 days interval.	2.5 g/40L Water

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	1100	801	878	926

Fenugreek

Particulars	***Rabi***
Crop	Fenugreek
Sowing/planting	First Fortnight of November
Harvesting	Second Fortnight of March
Variety	RMT-1

Important features of suitable variety

Variety	**RMT-1**
Duration (days)	140-150 Days
Average yield under organic condition (kg/ha)	1500-2000 Kg/ha.
Source (s) of availability	RSSC Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara,Chittorgarh,Banswara
Specific tolerance to drought/waterlogging	No

Field preparation:

Ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	20-25 Kg/ha.		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Neem cake	200 kg/ha	Soil application
	Rhizobium and Phosphorous Soliblizing Bacteria	500g each	To prepare make a solution by adding 250 g of

	(PSB culture)		jaggery in one litre of hot water. After cooling add 500 g/ha Rhizobium and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Trichoderma @ 8 g/kg seeds	160 g/ha	Seed treatment
Spacing (row x plant) in cm	30x5 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	6 tonnes	
	BD-500 in the evening before sowing	75 g/40L Water	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	BD-500	75 g/40L water	20 DAS in evening before sowing
	BD-501	2.5 g/40L water	20 DAS in morning 15 DAS

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Flowering & Pod formation	30 cm
Major weeds	*Convolvulus arvensis, Anglensis arvensis, Cornopus didymus, Chenopodium album, Chenopodium murele*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30 DAS & 50 DAS, if necessary	Hand weeding	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Powdery mildew	Three sprays of BD-501 First on appearance of disease and repeat after 15 days interval.	2.5 g/40 litre water
	Aphids	Two sprays of Neem oil (10ml/L) First on appearance of pest and repeat after 15 days interval.	10 ml/litre water

Yield

Year	**1st**	**2nd**	**3rd**	**Mean**
Economic yield (kg/ha)	1600	1655	1637	1631

Glimpses of Practices

BD-501

Neem oil spray

Organic Blackgram

Organic Fenugreek

Clusterbean

Details of crops in cropping systems

Particulars	***Kharif***
Crop	Cluster bean
Sowing/planting	First Fortnight of July
Harvesting	Second Fortnight of October
Variety	RGC-1017

Important features of suitable variety

Variety	**RGC-1017**
Duration (days)	90-99 days
Average yield under organic condition (kg/ha)	1000-1400 Kg/ha
Source (s) of availability	RSSC,Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara,Chttorgarh,Banswara

Field preparation:

1. Deep summer ploughing to hamper the population of soil born pest and disease pathogen.
2. Deep ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods. Level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	20 Kg/ha.		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium and Phosphorous Soliblizing Bacteria (PSB culture)	500g each	To prepare make a solution by adding 250 g of jaggery in one litre of hot water.

			After cooling add 500 g/ha Rhizobium and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Trichoderma incubated before sowing	2 Kg *Trichoderma* incubated on 100 Kg FYM for 15 days	Soil application
	Neem cake	200 Kg/ha	Soil treatment before sowing
Spacing (row x plant) in cm	30x10		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermi compost	1.2 tonnes	
	Matka Khad	200 L/Acre	
	Spray of BD-500	75 g/40 L Water in evening before sowing	
	Spray of BD-501	2.5 g/40L Water in morning 15 DAS	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Branching, flowering and pod formation	30 cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nutsedge	*Cyperus spp.*
	Bokna	Day flower	*Commelina benghalensis*
	Salara	White cock's comb	*Celosia arvensis*
	Kundra	Digera	*Digera arvensis*
	Sanwa ghas	Barnyard grass	*Echinochloa crusgalli*
	Kodon	Goosegrass	*Eleusine indica*
	Sathi	Horse purslane	*Trianthema portulacstrum*

	Doob ghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia spp.*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop growth, crop should be weed free up to 45 DAS	Weed control in organic systems, especially in organic cluster bean production, relies heavily on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional row pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at 45 DAS should be given. Smother cropping, intercropping and mulching reduce weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Dry root rot	2 kg *Trichoderma* incubated on 100 kg on FYM for 15 days	Trichoderma 2 kg/ha incubated on 100 kg FYM
	Blight complex (Alternaria and Bacterial blight) and Powdery mildew	Foliar sprays of neem oil at 35, 50 and 60 DAS.	2%
	Jassids	Sprays of NLE at vegetative stage, 50% flowering and pod formation stage	5%

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	645	800	716	720

Chickpea

Particulars	*Rabi*
Crop	Gram
Sowing/planting	First Fortnight of October
Harvesting	Second Fortnight of March
Variety	GNG-469 (Samrat)

Important features of suitable variety

Variety	GNG-469 (Samrat)
Duration (days)	145-147 days
Average yield under organic condition (kg/ha)	2000-2500 Kg/ha
Source (s) of availability	RSSC, Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara,Chttorgarh,Banswara, Kota
Specific resistance / tolerance to pest	Pod borer
Specific resistance / tolerance to disease	Root rot, wilt and collar rot
Specific tolerance to drought/waterlogging	No

Field preparation: Ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods, disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	80 Kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Neem cake	200 kg/ha	Soil application
	Rhizobium and Phosphorous Soliblizing Bacteria (PSB culture)	500g each	To prepare make a solution by adding 250 g of jaggery in one

			litre of hot water. After cooling add 500 g/ha Rhizobium and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Trichoderma incubated FYM before sowing	2 Kg *Trichoderma* incubated on 100 Kg FYM for 15 days	Soil application
Spacing (row x plant) in cm	30x10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermi compost basal	2 tonnes	
	Vermicompost at 40 DAS	2 tonnes	
	Mustard cake	1 tonnes	
	Spray of BD-500	75 g/40 L Water during evening before sowing	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Spray of BD-501	2.5 g/40L Water	in morning 20 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Flowering and pod formation	30 cm

Major weeds	*Convolvulus arvensis, Anglensis arvensis, Cornopus didymus, Chenopodium album, Chenopodium murale*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop growth, crop should be weed free up to 45 DAS	Weed control in organic gram, relies on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at 45 DAS should be given. Smother cropping, Intercropping and mulching reduce weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Dry root rot	Soil application of *Trichoderma* incubated on FYM	2 kg *Trichoderma* incubated on 100 Kg FYM for 15 days
	Pod borer	Inter cropping with mustard + HaNPV 250 LE at 50% flowering and pod formation	250 LE/ha

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	1843	1650	1752	1748

Glimpses of Practices

Matka Khad

Vermiwash

BD-500

Organic clusterbean

Organic gram

Sesame

Details of crops in cropping systems

Particulars	*Kharif*
Crop	Sesame
Sowing/planting	First Fortnight of July
Harvesting	Second Fortnight of October
Variety	RT-46

Important features of suitable variety

Variety	RT-46
Duration (days)	85-90 days
Average yield under organic condition (kg/ha)	1000-1200 Kg/ha
Source (s) of availability	RSSC , Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara, Chttor garh, Banswara

Field preparation:

1. Deep summer ploughing to hamper the population of soil born pest and disease pathogen.

2. Deep ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods. Level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	2-2.5 Kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azotobacter and Phosphorous Solubilizing Bacteria (PSB culture)	500g each	To prepare make a solution by adding 250 g of jaggery in one litre of hot water.

			After cooling add 500 g/ha Azotobacter and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Trichoderma @ 8 g/kg seeds	20 g/ha	Seed treatment
	Neem cake	200 Kg/ha	Soil application before sowing
Spacing (row x plant) in cm	30x10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	4 tonnes	
	Spray of BD-500	75 g/40 L Water before sowing	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Spray of BD-501	2.5 g/40L Water	an evening before sowing
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Branching and Flowering	30 cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nutsedge	*Cyperus spp.*
	Bokna	Day flower	*Commelina benghalensis*
	Salara	White cock's comb	*Celosia arvensis*
	Kundra	Digera	*Digera arvensis*

	Sanwa ghas	Barnyard grass	*Echinochloa crusgalli*
	Kodon	Goosegrass	*Eleusina indica*
	Sathi	Horse purslane	*Trianthema portulacstrum*
	Doob ghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia spp.*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop growth, crop should crop be weed free up to 30-35 DAS	Weed control in organic sesame, relies on rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 15 DAS and one hand weeding at 30 DAS should be given. Smother cropping, intercropping with groundnut and mulching reduce weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Phytophthera, Blight, Phyllody, Aphids and Pod borer	Seed treatment with *Trichoderma harzianum* (8 g/kg)+ three sprays of Azadirictin formulation (2 ml/L). First at 20-30 DAS, second 40 DAS and third 50 DAS.	

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	966	817	582	788

Cumin

Details of crops in cropping systems

Particulars	*Rabi*
Crop	Cumin
Sowing/planting	First Fortnight of November
Harvesting	Second Fortnight of March
Variety	RZ-19

Important features of suitable variety

Variety	RZ-19
Duration (days)	120 days
Average yield under organic condition (kg/ha)	1000 Kg/ha
Source (s) of availability	RSSC, Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara, Chittorgarh, Banswara

Field preparation: Ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	12-15 Kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Neem cake	200 kg/ha	Soil application
	Azotobactor and Phosphorous Soliblizing Bacteria (PSB culture)	500g	To prepare make a solution by adding 250 g jaggery in one litre of hot water. After cooling add 500 g/ha Azotobactor and 500 g/ha

			Phosphorous Solubilising Bacteria (PSB culture). Mix the thus prepared solution with seeds. After drying go for sowing.
	Trichoderma @ 8 g/kg seeds	120 g/ha	Seed treatment
Spacing (row x plant) in cm	30x5 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	6 tonnes	
	Spray of BD-500	75 g/40 L Water an evening before sowing	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Spray of BD-501	2.5 g/40L Water	in morning 20 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2-3	First at the time of sowing, second 7 DAS, third as and when required.	30 cm
Major weeds	*Convolvulus arvensis, Anglensis arvensis, Cornopus didymus, Chenopodium album, Chenopodium murale*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-35 DAS & 55-60 DAS.	Hand weeding and hoeing.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Aphids	Sprays of NSKE at 45 DAS and repeat after 15 days	5 % solution

	Blight	Sprays of Azadirictin formulation first at 45-60 DAS and repeat second & third spray at 15 days interval.	2 ml/L Water
	Powdery mildew	a. Sprays of BD-501. First in first week of February and second in third week of February.	a. 2.5 g/40 L Water
		b. Sprays of milk whey. First in second week of February and second in fourth week of February.	b. 10 %

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	524	371	655	517

Organic Sesame

Organic Cumin

Groundnut

Particulars	***Kharif***
Crop	Groundnut
Sowing/planting	Fortnight of July
Harvesting	Fortnight of October
Variety	TAG-24

Important features of suitable variety

Variety	**TAG-24**
Duration (days)	100 -120 days
Average yield under organic condition (kg/ha)	Pod yield 1400 Kg/ha
Source (s) of availability	RSSC ,Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara,Chttorgarh,Banswara
Specific tolerance to drought/waterlogging	No

Field preparation:

1. Deep summer ploughing to hamper the population of soil born pest and disease pathogen.
2. Deep ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	120 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium and Phosphorous	500g each	To prepare make a solution by

	Soliblizing Bacteria (PSB culture)		adding 250 g of jaggery in one litre of hot water. After cooling add 500 g/ha Rhizobium and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Trichoderma @ 8 g/kg seeds	960 g/ha	Seed treatment
	Neem cake	200 Kg/ha	Soil treatment before sowing
Spacing (row x plant) in cm	30X10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Vermicompost	1 tonnes	
	Rock phosphate	0.35 tonnes (equivalent to 60 kg P)	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Spray of BD-500	75 g/40 L Water	an evening before sowing
	Spray of BD-501	2.5 g/40L Water	in morning 15 DAS

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Branching, flowering and pod formation	30 cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nutsedge	*Cyperus spp.*
	Bokna	Day flower	*Commelina benghalensis*
	Salara	White cock's comb	*Celosia arvensis*
	Kundra	Digera	*Digera arvensis*
	Sanwa ghas	Barnyard grass	*Echinochloa crus galli*
	Kodon	Goosegrass	*Eleusine indica*
	Sathi	Horse purslane	*Trianthema portulacstrum*
	Doobghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia spp.*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop	Weed control in organic groundnut, relies on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at	

		45 DAS should be given. Smother cropping, intercropping and mulching reduce weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Aphids and Thrips	Neem leaf extract at 10-20 DAS	10%
		NSKE at 30-40 DAS	5%
		Neem oil at 50-60DAS	2%
	Collar rot	Seed Treatment with *Trichoderma*	8gm/kg
	Leaf spot	Neem leaf extract at 10-20 DAS	10%
		NSKE at 30-40 DAS	5%
		Neem oil at 50-60DAS	2%

Yield

Year	1st	2nd	3rd	Mean
Economic Pod yield (kg/ha)	1377	1438	1391	1402

NADEP compost preparation at MPUAT, Uadipur

Indigenous panchagavya preparation at MPUAT, Udaipur

Mustard

Particulars	***Rabi***
Crop	Mustard
Sowing/planting	First to second fortnight of october
Harvesting	First fortnight of March
Variety	Laxmi

Important features of suitable variety

Variety	**Laxmi**
Duration (days)	120 days
Average yield under organic condition (kg/ha)	2000 kg/ha
Source (s) of availability	RSSC,Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara,Chttorgarh,Banswara

Field preparation: Deep ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	5 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azotobactor and Phosphorous Solubilizing Bacteria (PSB culture)	500g each	To prepare make a solution by adding 250 gjaggeryin one litre of hot water. After cooling add 500 g/ha Azotobactor and 500 g/ha Phosphorous Solubilizing Bacteria (PSB

			culture). Mix the thus prepared solution with seeds. After drying go for sowing.
	Trichoderma incubated FYM before sowing	2 Kg *Trichoderma* incubated on 100 Kg FYM for 15 days	Soil application
	Neem cake	200 Kg/ha	Soil application before sowing
Spacing (row x plant) in cm	30X10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Poultrymanure	1.7 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Spray of BD-500	75 g/40 L Water	an evening before sowing
	Spray of BD-501	2.5 g/40L Water	in morning 15 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Branching, flowering and pod formation	30 cm
Major weeds	*Convolvulus arvensis, Anglensis arvensis, Cornopus didymus, Chenopodium album, Chenopodium murale*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop growth, crop should be weed free up to 45 DAS	Weed control in organic Mustard, reiles on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand	

		weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at 45 DAS should be given. Smother cropping, Intercropping and mulching reduce weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Aphid	spray of *Azadirachtin* at 5-10 DAS	0.3 %
		Neem oil at 10-20 DAS	2%
		NSKE at 30-40 DAS	5%
		Cow urine at 50-60 DAS	10%
		Milk Whey at 60-75 DAS	10%
	Alternaria blight and powdery mildew	spray of *Azadirachtin* at 5-10 DAS	0.3 %
		Neem oil at 10-20 DAS	2%
		NSKE at 30-40 DAS	5%
		Cow urine at 50-60 DAS	10%
		Milk Whey at 60-75 DAS	10%

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	2032	1877	1988	1966

Organic groundnut

Organic mustard

Groundnut

Details of crops in cropping systems

Particulars	***Kharif***
Crop	Groundnut
Sowing/planting	First Fortnight of July
Harvesting	Second Fortnight of November
Variety	TG-37 A

Important features of suitable variety

Variety	**TG 37 A**
Duration (days)	125
Average yield under organic condition (kg/ha)	2860
Source (s) of availability	NSC
Suitable regions/districts in the state	Banswara

Field preparation: A required tilth may be obtained by ploughing twice with mould board plough followed by two harrowings and plankings. Organic manures and gypsum should be spread and mixed well in the soil with final harrowing at least 15-20 days before sowing. Green manuring should be incorporated in standing crop at 20 DAS and band application of gypsum between rows and incorporated before flowering of crop.

Cultural practices

Seed rate (kg/ha)	100 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium Culture	500 g each	To prepare make a solution by adding 250 g of jaggery in one litre of hot water. After cooling add

			500 g/ha Rhizobium and 500 g/ha Phosphorous Solubilising Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Garlic clove extract (10%)	5 ml garlic clove extract /kg seeds	Seed treatment
	Or *Trichoderma* @ 10g/kg seeds	1kg/ha	Seed treatment
Spacing (row x plant) in cm	30x15cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	4 tonnes	
	Rock phosphate	260 kg	
	Gypsum	250 kg	
	BD 500	75 g/40 lit water/ha in evening time, one day before sowing	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Gypsum	250 kg	Applied between rows and incorporated with hoeing before flowering
	BD 501	2.5 g/40 lit water	At 45 DAS

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	One irrigation is requires during *kharif* season, if the crop is caught in a long drought spell, especially at Pod formation stage.	Branching, flowering and pod formation	15 cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nutsedge	*Cyperus spp.*
	Bokna	Day flower	*Commelina benghalensis*
	Salara	White cock's comb	*Celosia arvensis*
	Kundra	Digera	*Digera arvensis*
	Sanwa ghas	Barnyard grass	*Echinochloa crusgalli*
	Kodon	Goosegrass	*Eleusine indica*
	Sathi	Horse purslane	*Trianthema portulacstrum*
	Doob ghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia spp.*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	It is essential to keep	Weed control in organic groundnut, relies on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. Hoeing between plants eliminates weeds in the	

		planting row. Flame weeding and other thermal devices can reduce broadleaf weeds, but grasses still need to be mechanically removed. Polythene mulching has been found effective in controlling weeds.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Early and late Leaf spot	Seed treatment with *Trichoderma* @ 10g/kg seeds	1kg/ha
		Seed treatment garlic extract (10%)	5 ml garlic clove extract /kg seeds
		Spray with garlic extract (10%)	50 ml garlic clove extract /ha/ 450 lit water
	Groudnut leaf minor	Timely sowing (June). Intercropping with soybean.	Groundnut+ soybean (2:2 ratio)
		Neem cake application	250 kg/ha/
		/Neem oil	5 ml/litre water
	Tobacco caterpillar	*Trichogramma*	At 15, 30 & 55 DAS @ 50,000/ ha.
		SlNPV	250 LE/ha
		Bt formulatipon/fungus, *Nomureae rileyi*	1kg/ha
		Plant extracts with *Vitex negundo* (Nirgundi leaves)	20% spray + teepol

Yield

Year	1st	2nd	3rd	Mean
Economic pod yield (kg/ha)	2253	2235	3548	2679

Glimpses of Practices

Organic manures and bio-fertilizers used in experiment trial

Manures and biofertilizer used in Groundnut crop

Field view of groundnut crop

Organic groundnut produce from field

Wheat

Particulars	***Rabi***
Crop	Wheat
Sowing/planting	First Fortnight of December
Harvesting	Second Fortnight of April
Variety	Raj. 4037

Important features of suitable variety

Variety	**Raj-4037**
Duration (days)	120
Average yield under organic condition (kg/ha)	3500-3800
Source (s) of availability	RSSCL, Banswara
Suitable regions/districts in the state	Banswara, Udaipur, Pratapgarh
Specific resistance / tolerance to disease	Rust , Smut

Field preparation: One deep ploughing with M.B. plough immediately after harvesting of groundnut crop and to give a pre-sowing irrigation, When field come in condition, broad casting of FYM, Rock phosphate and gypsum should be mixed with field preparation by giving two cross harrowing followed by planking to make the field levelled and to minimize the loss of moisture from soil surface.BD 500 should be sprayed on soil surface before last ploughing.

Cultural practices

Seed rate (kg/ha)	150kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azotobacter and PSB	500g each	To prepare make a solution by adding 250 g of jaggery in one litre of hot water. After cooling add 500 g/ha

			Azotobacter and 500 g/ha Phosphorous Solubilising Bacteria (PSB culture). Mix the thus prepared solution with seeds. After drying go for sowing.
	Hot water seed treatment	52°C for 10 min	First soak seeds in cold water then soak in hot water (52°C) for 10 min and dry in shad.
Spacing (row x plant) in cm	22.5x5.0cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	24 tonnes	
	Gypsum	500 kg	
	BD 500	75 g/40 liter water	
	Vermicompost	1.8 tonnes	
	Neem cake	1.2 tonnes	
	Poultry manure	2 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Green leaf manure of subabul lops	15 t/ha	Spreading just after sowing
	Vermicompost	1.8 t/ha	Before second irrigation
	Neem cake	1.2 t/ha	Before second irrigation
	Poultry manure	2 t/ha	Before second irrigation
Irrigation practices	4	CRI, tillering, booting and milking	10-15 cm at each stage
Major weeds	**Local Name**	**English name**	**Scientific name**
	Moth	Nutsedge	*Cyperus spp.*
	Doob ghas	Bermuda grass	*Cynodon dactylon*

	Gajar ghas	Congress grass	*Parthenium hysterophorus*
	Bathua	Lambs quarters	*Chenopodium album*
	Kharbadua	Goose foot	*Chenopodium murale*
	Krishnaneel	Blue pimpernel	*Anagalis arvensis*
	Piazi	Wild onion	*Asphodelus tenuifolius*
	Gullidanda	Canary-grass	*Phalaris minor*
	Janglijai	Wild oat	*Avena fatua*
	Hirankhuri	Field bindweed	*Convolvulus arvensis*
	Gajari	Pitpapra	*Fumaria pasviflora*
	Metha	Sweet clover	*Melilotus alba*
	Jangli palak	Jangli palak	*Rumax retroflex*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	It is essential to keep wheat fields weed free for up to 45 days after crop emergence	Weed control in organic wheat, relies on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. Hoeing between plants eliminates weeds in the planting rows at 30-35 DAS.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Termite	Neem cake	250 kg/ha
		Fungus, *Metarhizium anisopliae*	Seed treatment: 10 g/kg seed Soil application: 10-15 kg/ha

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	2190	3458	3867	3172

Glimpses of Practices

Manures and biofertilizer used in Wheat crop

FYM+Gypsum+biofertlizer with BD 500 in wheat crop

Field view of organic crop of wheat

Castor

Particulars	***Kharif***
Crop	Castor
Sowing/planting	First Fortnight of August
Harvesting	Second Fortnight of November
Variety	GCH-7

Important features of suitable variety

Variety	**GCH-7**
Duration (days)	189
Average yield under organic condition (kg/ha)	1837
Source (s) of availability	NSC, Udaipur
Suitable regions/districts in the state	Banswara

Field preparation: Deep ploughing is necessary to break up any compact layers in the soil so that roots can penetrate deep in the soil to obtain moisture from depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	15kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azotobacter culture	500 g each	To prepare make a solution by adding 250 g of jaggery in one litre of hot water. After cooling add 500 g/ha

			Azotobacter and 500 g/ha Phosphorous Solubilising Bacteria (PSB culture). Mix the thus prepared solution with seeds. After drying go for sowing.
	Trichoderma @ 10 g/kg seeds	150 g/ha	Seed treatment
Spacing (row x plant) in cm	90x45cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	8 tonnes	
	Rock phosphate	120 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Sesbania green manuring	60t/ha	30-35 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Flowering	30cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nutsedge	*Cyperus spp.*
	Bokna	Day flower	*Commelina benghalensis*

	Salara	White cock's comb	*Celosia arvensis*
	Kundra	Digera	*Digera arvensis*
	Senwa ghas	Barnyard grass	*Echinochloa crusgalli*
	Kodon	Goosegrass	*Eleusine indica*
	Sathi	Horse purslane	*Trianthema portulacstrum*
	Doob ghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia spp.*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of growth. Crop should be weed free up to 60 DAS	Weed control in organic castor, relies on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at 60 DAS should be given. Smother cropping, intercropping and mulching should be reduced weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Wilt	Seed treatment with *Trichoderma* @ 10g/kg seeds	150 g/ha

		Soil application with *Trichoderma* enriched FYM	15 kg formulation enriched in 10 t FYM/ha
		Or Soil application with Neem cake	500 kg /ha
	Sucking pests(Jassids)	Or Soil application with Neem cake	250 kg/ha
		Neem oil (5%)	5 ml/liter water
	Tobacco caterpillar	Neem oil (5%)	5 ml/liter water
		SlNPV	250 LE
		Trichogramma	50, 000/ha (@30 DAS
		Bt formulation/ fungus, *Nomureae rileyi*	2 g/litre) (30 & 60 DAS)
		Spraying of botanical formulation	20 % of the formulation

Yield

Year	**1st**	**2nd**	**3rd**	**Mean**
Economic pod yield (kg/ha)	1765	1910	2138	1938

Glimpses of Practices

Manures and biofertilizer used in Castor crop

Trichogramma cards in castor crop

Crop view of organic crop of castor

Greengram

Particulars	Summer
Crop	Greegram
Sowing/planting	First Fortnight of April
Harvesting	Second Fortnight of June
Variety	SML-668

Important features of suitable variety

Variety	SML-668
Duration (days)	60
Average yield under organic condition (kg/ha)	532
Source (s) of availability	RSSCL, Banswara
Suitable regions/districts in the state	Banswara

Field preparation: For summer moong crop, one deep ploughing with M.B. plough immediately after harvesting of castor crop and to give a pre-sowing irrigation, When field come in condition, broad casting of FYM, Rockphosphate and gypsum and incorporated with field preparation by giving two cross harrowing followed by planking to make the field levelled and to minimize the loss of moisture from soil surface.BD 500 should be sprayed on soil surface before last ploughing.

Cultural practices

Seed rate (kg/ha)	20kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium Culture and Phosphorus solubilises Bacteria (PSB) culture	500 g each	To prepare make a solution by adding 250 g of jaggery in one litre of hot water. After cooling add

			500 g/ha Azotobacter and 500 g/ha Phosphorous Solubilising Bacteria (PSB culture). Mix the thus prepared solution with seeds. After drying go for sowing.
Spacing (row x plant) in cm	25x10cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	4 tonnes	
	Rock phosphate	120 kg	
	Gypsum	250 kg	
	BD 500	75 g/40 lit water	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	Gypsum	250kg/ha	Before flowering
	BD 500	75g/40 lit water/ ha	At 45DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3-4 irrigations, first irrigation should be given about 20-25 DAS. The subsequent irrigation should be given at an interval of 12-15 days	Branching, flowering and seed filling stage	15cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nutsedge	*Cyperus spp.*

	Sathi	Horse purslane	*Trianthema portulacstrum*
	Kundra	Digera	*Digera arvensis*
	Senwa ghas	Barnyard grass	*Echinochloa crusgalli*
	Kodon	Goose grass	*Eleusine indica*
	Doob ghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia spp.*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	It is essential to keep groundnut fields weed free for up to 45 days after crop emergence	Weed control in organic moong, relies on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. One mechanical hoeing and weeding should be necessary to eliminates weeds at 25-30 DAS	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Yellow mosaic, Whitefly (Vector)	NSKE (two sprays)	2 lit /ha/500 lit water
		Perfekt™ (Global green Agrinova Bangaore) Herbal bio product (Two sprays)	500 ml per ha/ 500 lit water
	Whitefly	*Verticillium lecanii*	1 lit /ha/500 lit water

Economic yield (kg/ha)	607

Glimpses of Practices

Manures and biofertilizer used in summer greengram

Crop view of organic crop of greengram

Farm waste inoculation tank

Maize

Particulars	***Kharif***
Crop	Maize
Sowing/planting	First Fortnight of July
Harvesting	Second Fortnight of October
Varieties	Pratap Makka-5, Pratap QPM hybrid -1, Pratap hybrid maize-3 and PM-3

Important features of suitable varieties

Parameters	**Pratap Makka-5 hybrid -1**	**Pratap QPM maize-3**	**Pratap hybrid**	**PM-3**
Duration (days)	85-90 Days	95-105 days	75-78 days	75-78 Days
Average yield under organic condition (kg/ha)	4500-5000 kg/ha.	900-1000 kg/ha.	4000-4500 kg/ha.	4000-4500 kg/ha.
Source (s) of availability	RSSC, Udaipur	RSSC, Udaipur	RSSC, Udaipur	RSSC, Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara, Chittorgarh, Banswara, Kota	Udaipur, Bhilwara, Chittorgarh, Banswara, Kota	Udaipur, Bhilwara, Chittorgarh, Banswara, Kota	Udaipur, Bhilwara, Chittorgarh, Banswara, Kota

Field preparation:

1. Deep summer ploughing to hamper the population of soil born pest and disease pathogen.

2. Deep ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	20-25 Kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Neem cake	200 Kg/ha	Soil treatment before sowing

	Azotobactor and Phosphorous Solubilizing Bacteria (PSB culture)	500 g each	To prepare make a solution by adding 250 g of jaggeryin one litre of hot water. After cooling add 500 g/ha Azotobactor and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Sead treatment with *Trichoderma*	8 g/Kg seed	Seed treatment
Spacing (row x plant) in cm	65x25 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	13.5 tonnes	
	Sead treatment with *Trichoderma*	8 g/Kg seed	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	4	Tassling and silking	30 cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nutsedge	*Cyperus spp.*
	Bokna	Day flower	*Commelina benghalensis*
	Salara	White cock's comb	*Celosia arvensis*
	Kundra	Digera	*Digera arvensis*
	Sanwaghas	Barnyard grass	*Echinochloa crusgalli*
	Kodon	Goosegrass	*Eleusine indica*
	Sathi	Horse purslane	*Trianthema portulacstrum*

	Doob ghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia spp.*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop growth, crop should be weed free up to 45 DAS	Weed control in organic maize, relies on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at 45 DAS should be given. Smother cropping, intercropping with blackgram (2:2) and mulching reduce weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Stem borer, Aphid, grass hopper	Sead treatment with *Trichoderma*	8 g/kg seed
		Spray of NSKE at 3, 10 and 35 DAS	5 %
	Leaf spot, downy mildew, stalk rot	Release of *Trichogramma* parasitoid at 7, 14 and 50 DAS	1.5 lacs/ha
		Spray of Bt formulation at 10 and 60 DS	1 L/ha

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	5033	4352	4224	4536

Wheat (Durum)

Particulars	***Rabi***
Crop	Wheat
Sowing/planting	First Fortnight ofNovember
Harvesting	First Fortnight of April
Varieties	HI-8498, HI-1531

Important features of suitable varieties

Parameters	**HI-8498**	**HI-1531**
Duration (days)	110-120 Days	110-120 days
Average yield under organic condition (kg/ha)	5000-6000 kg/ha	2500-3000 kg/ha
Source (s) of availability	NSC, Udaipur	NSC, Udaipur
Suitable regions/districts in the state	Udaipur, Bhilwara, Chittorgarh,Banswara, Kota	Udaipur, Bhilwara, Chittorgarh, Banswara, Kota

Field preparation: Ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	100 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	FYM	13.5 t/ha	
	Azotobacter and Phosphorous Solubilizing Bacteria (PSB culture)	500 g each	To prepare make a solution by adding 250 g of jaggery in one litre of hot water. After cooling add

			500 g/ha Azotobacter and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepared solution with seeds. After drying go for sowing.
	Seed treatment with *Trichoderma*	800 g/ha	Seed treatment
	Gypsum	500kg/ha	Soil application
Spacing (row x plant) in cm	22.5 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	13.5 t/ha	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/planting or stage of crop**
	BD-500	75 g/ 40 L	Foliar spray
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	6	CRI, Late jointing and milking	30 cm
Major weeds	*Convolvulus arvensis, Anglensis arvensis, Cornopus didymus, Chenopodium album, Chenopodium murale*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop growth, crop should	Weed control in organic wheat, relies on crop rotations, cover crops and mulching.	

	be weed free up to 45 DAS	For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at 45 DAS should be given. Smother cropping, intercropping and mulching reduce weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Termite	Seed treatment with Fungus *Metarhizium anisopliae*	10 g/kg seed

Yield

Year	1st	2nd	3rd	Mean
Economic yield (q/ha)	5055	4458	4296	4603

Organic Maize

Organic Wheat (Durum)

Soybean

Particulars	***Kharif***
Crop	Soybean
Sowing/planting	First fortnight of July
Harvesting	First fortnight of October
Variety	JS-335

Important features of suitable variety

Variety	**JS-335**
Duration (days)	95-100
Average yield under organic condition (kg/ha)	2500-3000 Kg/ha
Source (s) of availability	RSSC, Udaipur
Suitable regions/districts in the state	Kota, Jhalawar, Baran, Bundi, Pratapgarh, Chhitorgarh,Banswara

Field preparation:

1. Deep summer ploughing to hamper the population of soil born pest and disease pathogen.
2. Deep ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	80 Kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium and Phosphorous Solubilising Bacteria (PSB culture)	500g	To prepare make a solution by adding 250 g of jaggery in one litre of hot water. After cooling add 500 g/ha Rhizobium and 500 g/ha

			Phosphorous Solubilising Bacteria (PSB culture). Mix the thus prepared solution with seeds. After drying go for sowing.
	Trichoderma @ 8 g/kg seeds	640 g/ha	Seed treatment
	Neem cake	200 Kg/ha	Soil treatment before sowing
Spacing (row x plant) in cm	30x5		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM or Vermicompost	FYM-6 tonnes Or Vermicompost 2 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Flowering & Pod formation	30 cm
Major weeds	**Local Name**	**English name**	**Scientific name**
	Motha	Nuts edge	*Cyperus spp.*
	Bokna	Day flower	*Commelina benghalensis*
	Salara	White cock's comb	*Celosia arvensis*
	Kundra	Digera	*Digera arvensis*
	Sanwa ghas	Barnyard grass	*Echinochloa crusgalli*
	Kodon	Goose grass	*Eleusine indica*
	Sathi	Horse purslane	*Trianthema portulacstrum*
	Doob ghas	Bermuda grass	*Cynodon dactylon*
	Congress ghas	Parthenium	*Parthenium hysterophorus*
	Hazardana	Hazardana	*Phyllanthus niruri*
	Dooddi	Euphorbia	*Euphorbia spp.*

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop growth, crop should be weed free up to 30-45 DAS	Weed control in organic soybean, relies on crop rotations, cover crops and mulching. For cultivation to be successful, a straight, well prepared bed, as well as straight seeding lines in a conventional diamond pattern is necessary for operation of cultivating implements to remove the most weeds while leaving the crop undisturbed. To keep the weeds down, two hand weedings, one mechanical weeding and hoeing at 30 DAS and one hand weeding at 45 DAS should be given. Smother cropping, intercropping with blackgram (2:2) and mulching reduce weed density in the field.	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Grass hopper, Stem & Leaf boer, Gurdle beetle, Semi looper Yellow Mosaic Virus, Bacterial blight, Stem & Collar rot and Leaf blight	a. Bird parches	a. 40-50/ha
		b. Spray of Azadirictin formulation 1500ppm	b. 5 ml/L Water
		c. Release of *Trichogramma* parasitoids at 30DAS	c. 1 lakh/ha
		d. Spray of Bt formulation at 50 DAS	d. 1 L/ha
		e. Seed treatment with cow urine (1:10) and Asafoetida (0.1%) solution.	e. cow urine (1:10) and Asafoetida (0.1%) solution.
		f. Spray of 20-30 days fermented milk whey at 30 & 45 DAS.	f. 10 ml/L Water

Yield

Year	**1st**	**2nd**	**3rd**	**Mean**
Economic yield (kg/ha)	1380	1485	652	1172

Coriander

Particulars	***Rabi***
Crop	Coriander
Sowing/planting	FirstFortnight of November
Harvesting	First Fortnight of March
Variety	CS-6

Important features of suitable variety

Variety	**CS-6**
Duration (days)	150
Average yield under organic condition (kg/ha)	8-10 Kg/ha
Source (s) of availability	RSSC
Suitable regions/districts in the state	Kota

Field preparation:

Ploughing is necessary to break up any compact layers in the soil so that root can penetrate deep in the soil to obtain moisture from the depth during dry periods. Disk harrowing should follow ploughing to break up clods, level the seedbed with planking.

Cultural practices

Seed rate (kg/ha)	20 Kg/ha.		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Neem cake	200 kg/ha	Soil application
	Azotobator and Phosphorous Soliblizing Bacteria (PSB culture)	500g	To prepare make a solution by adding 250 g of jaggery in one

			litre of hot water. After cooling add 500 g/ha Azotobactor and 500 g/ha Phosphorous Solubilizing Bacteria (PSB culture). Mix the thus prepred solution with seeds. After drying go for sowing.
	Trichoderma @ 8 g/kg seeds	160 g/ha	Seed treatment
Spacing (row x plant) in cm	30x5 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Green manuring (Dhaincha)		
	FYM or Vermicompost	FYM- 5 tonnes Or Vermicompost- 1.67 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	2	Branching and Seed formation	
Major weeds	*Convolvulus arvensis, Anglensis arvensis, Cornopus didymus, Chenopodium album, Chenopodium murale*		

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30-35 DAS & 55-60 DAS	Hand weeding & hoeing	
Organic plant protection practices	**Name of pest/disease**	**Organic material recommended for control**	**Quantity**
	Aphids	a. Yellow sticky traps	a. 10-15/ha
		b. Spray of Azadirictin formulation 500ppm	b. 5 ml/L Water
	Wilt	Seed treatment with *Trichoderma viride*	8 g/Kg seed

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	1271	1002	599	957

Organic Soybean

Organic Coriander

SIKKIM

Suggested cropping systems (Based on Testing by ICAR-National Organic Farming Research Institute Tadong, Gangtok)

For Rainfed areas

1. Maize (green cobs)-black gram (pahenlo dal)-buckwheat
2. Maize+beans-vegetable pea
3. Maize+beans-rajmash
4. Maize+beans-toria

For Irrigated areas

1. Rice-vegetable pea-maize (green cobs)
2. Rice-fenugreek (leafy vegetable)-baby corn
3. Rice-sunflower-*Dhaincha* (green manuring)
4. Rice-vegetable pea

Details of crops in cropping systems

For rainfed areas

Maize (green cobs)

Particulars	**Summer**	***Kharif***	***Rabi***
Crop	Maize	Buckwheat	Pahenlo dal
Sowing/planting	April	December	August
Harvesting	July	March	November
Varieties	RCM 1-76 Vivek QPM -9 HQPM-1	Mithey PRB-1	PD-3

Important features of suitable varieties

Varieties	**RCM 1-76**	**Vivek QPM-9**
Duration (days)	105-110	100-105
Average yield under organic condition (t/ha)	6200 (green cobs)	7500 (green cobs)

Cultural practices

Seed rate (kg/ha)	20-25 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Biofertilizer (*Azospirillum* spp.), Phospho-bacteria	600 g/ha 600 g/ha	Seed treatment
Spacing (row x plant) in cm	50 × 20		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	8.0 tonnes	
	Vermicompost	1.0 tonnes	
	Azospirillum spp.	2.0 kg	
	PSM	2.0 kg	
	Neem cake	0.5 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Crop grown totally under rainfed condition. Therefore no irrigation has been given		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	45 days after sowing	Use of weed biomass/ tree leaves mulch between the rows	

Organic plant protection practices	Name of pest/ disease	Recommended organic material/ practices used for control	Quantity/ m^2 area
	Diseases: Turcicum leaf blight (*Helminthosporium turcicum*) Maydis leaf blight (*Bipolaris maydis*) Bacterial stalk rot (*Erwinia carotovora, Erwinia chrysanthemi*)		
	Insect pests: Cut worm, Stem borer, Army worm, Semi-looper, Cob borer and Bird damage	1. Hand picking or trapping of adult moths 2. Crop rotation 3. Change in sowing and harvesting timings 4. Spray neem formulations 1500 ppm @3ml/l or Spinosad 45 SC @ 0.3 ml/l	

Yield

Economic yield	Average 6000 kg

Blackgram (Pahenlo dal)

Variety	**PD-3**
Duration (days)	115-120
Average yield under organic condition (kg/ha)	650

Cultural practices

Seed rate (kg/ha)	20-25		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate (kg/ha or litre/ha)**	**Method of application**
	Rhizobium	400 g	Seed treatment
	PSB (Phosphate Solubilizing Bacteria)	400 g	
Spacing (row × plant) in cm	30 x 10		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	5 tonnes	
	Vermicompost	2.5 tonnes	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	Pre-flowering stage		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	10-40 DAS	Hand weeding	
		Farm litter mulch @ 5 t/ha	
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material/ practices used for control**	**Quantity/m^2 area**
	Diseases: Anthracnose (*Colletotrichum lindemuthianum*), Yellow mosiac virus rust	Field sanitation. Application of wettable sulphur @0.25%. Spray neem oil.	
	Insect pests: Pod sucking bugs (*Riptortus spp*) bihar hairy caterpillar (*Spilosoma obliqua)*	Spray Spinosad 45 SC @0.3 ml/l. Removal and destruction of early stage larvae.	

Yield

Economic yield (kg/ha)	750

Buckwheat

Important features of suitable varieties

Varieties	Mithey	PRB-1
Duration (days)	105-110	108-115
Average yield under organic condition (kg/ha)	1100	1120

Cultural practices

Seed rate (kg/ha)	35-40		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azophos seed treatment+mixed compost+neem cake Or vermicompost	Azophos @ 800 g/ha 5 t/ha +0.5 t/ha or vermicompost 1.5 t/ha	Seed treatment and soil application
Spacing (row x plant) in cm	30-45 row to row, 10-15 plant to plant		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	One weeding and hoeing at 20-25 DAS is helpful for raising a good crop	Crop should be seeded into a fine, firm and weed-free seedbed. Secondly, the seed should be placed into moist soil to ensure quick germination and emergence.	
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material/ practices used for control**	**Quantity**
	Diseases		
	Downy mildew	Selection of seeds from disease free plants	

		Sowing of healthy seeds and seed treatment with *Trichoderma viride.* Soil application of *Trichoderma viride*	4 g of seed
	Powdery mildew	Sowing of healthy seeds and application of wettable sulfur	0.25%
	Pests		
	Bruchids (*Acanthecelids obtectus*), grain moth (*Cephitinea* spp.), cut worm (*Cirphis* spp.), storage beetles (*Mycetophagus* spp.) and aphids		

Yield

Economic yield (kg/ha)	1125

Maize+beans based cropping sequences

Land preparation

- A good seed bed should consist of 5 to 7 cm of fine firm soil that is free from weeds.
- To achieve this fine seedbed, traditional farmer practice is to deep plough immediately after harvest of the *kharif*/*rabi* crops. It helps in early sowing of the crop after ploughing the land once or twice followed by one harrowing.

- After harvesting of maize, around 30 per cent residue (maize stalk) should be retained for mulching (conservation agriculture/minimum tillage) in *rabi* sown crop (vegetable pea), which have the ability to reduce soil temperature, crusting of soil surface, surface evaporation, emergence of weeds, soil erosion, sand-blasting damage to seedlings and improve infiltration rate and finally increased productivity of maize+bean -vegetable pea system.

- Mulching (residue retention of previously harvested crop) has the potential to reduce the risk of crop failure as a result of drought, especially during the winter season.

Maize

Important features of suitable variety

Variety	**Vivek QPM-9**
Duration (days)	130-135
Average yield under organic condition (kg/ha)	4200

Cultural practices

Seed rate (kg/ha)	20-25		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Biofertilizer (*Azospirillum* spp.) Phospho-bacteria	600 g/ha	Seed treatment
Spacing (row × plant) in cm	50 × 20		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	8.0 tonnes	
	Vermicompost	1.0 tonnes	
	Azospirillum spp.	2.0 kg	
	PSM	2.0 kg	
	Neem cake	0.5 tonnes	

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	45 days after sowing	Use of weed biomass/ tree leaves mulch between the rows
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material/ practices used for control**
	Diseases: Turcicum leaf blight (*Helminthos poriumturcicum*) Maydis leaf blight (*Bipolaris maydis*) Bacterial stalk rot (*Erwinia carotovora, Erwinia chrysanthemi*)	
	Insect pests: Cut worm, Stem borer, Army worm, Semi-looper, Cob borer and Bird damage	1. Hand picking or trapping of adult months 2. Crop rotation 3. Change in sowing and harvesting timings 4. Spray neem formulations 1500 ppm @3 ml/l or Spinosad 45 SC @ 0.3 ml/l

Yield

Economic yield (kg/ha)	4100 (maize) and 4500 kg (green pod of cowpea)

Rabi crops

Cultural practices	Vegetable pea	Rajmash	Toria
Land preparation	After harvesting of maize, around 30 per cent residue (maize stalk) should be retained for mulching (conservation agriculture/minimum tillage) in vegetable pea.	A good seed bed should consist of 5 to 7 cm of fine firm soil that is free from weeds. After harvesting of maize, around 30 per cent residue (maize stalk) should be retained for mulching (conservation agriculture/minimum tillage), which have the ability to reduce soil temperature, crusting of soil surface, surface evaporation, emergence of weeds, soil erosion, sand-blasting damage to seedlings and improve infiltration rate	The land should be well prepared first by 2-3 deep ploughing with soil turning plough, followed by two cross-harrowing after harvesting of maize results in good germination and uniform stand of the crop.
Organic manure application	Vermicompost or neem cake @ 1.0 t/ha in furrows open for sowing of the seeds.	Apply vermicompost or neem cake @ 1.0 t/ha in furrows open for sowing of the seeds.	Application of mixed compost @ 5 t/ha + vermicompost @ 1.0 t/ha + neem cake @ 1.0 t/ha + dolomite @ 1.0 t/ha should be applied
Time of sowing	End of September	End of September	End of September
Varieties	Kanshi Udai	SKMR-57	M-27, B-9,SYS-1
Seed rate	100 kg/ha	100 kg seed/ha	4 kg seed/ha
Spacing	30 cm × 10 cm	30 cm x 10 cm	30 cm x 10-15 cm
Water management	Since vegetable pea grown as rainfed crop, hence, proper mulching of maize stalk and weed	Since Rajmash has been grown as a rainfed crop, hence, proper mulching	Since toria has been grown as a rainfed crop, hence, proper mulching of maize stalk should

	biomass should be done.	of maize stalk should be done. If irrigation water is available then apply supplemental irrigation at pre pod formation stage.	be done.
Weed management	The critical period of crop weed competition is 40 days after sowing. One hand weeding, first at 30 DAS	The critical period of crop weed competition is 40 days after sowing. Two hand weeding, first at 15-20 DAS and second at 40-45 DAS should be done to get the optimum yield.	The critical period of crop weed competition is 45 days after sowing. One hand weeding at 15-20 DAS should be done to get the optimum yield. Use of weed biomass/ tree leaves' mulch between the rows is one of the best alternatives of hand weeding under organic weed management conditions.
Harvesting	First picking 85-95 days after sowing	85-90 days after sowing	110-115 days after sowing

For Irrigated areas

1. Rice-vegetable pea-maize (green cobs)
2. Rice-fenugreek (leafy vegetable)-baby corn
3. Rice-sunflower-dhaincha (green manuring)
4. Rice-vegetable pea

Land preparation

- The land should be properly prepared with two-three ploughing and uniform levelling with peripheral bund.

- Puddling may be done two-three times to make it weed-free and water retentive.
- Excessive tillage results in degradation of soil quality, causes soil and nutrient loss through erosion during heavy rains and finally leads to yield reduction.
- Organic manures like farmyard manure or composts should be applied about 15 days before transplanting and mixed with the soil during ploughing.

Rice

Important features of suitable varieties

Varieties	Sasharang	Attey local
Duration (days)	145-155	160-165
Average yield under organic condition (kg/ha)	4100	2300

Nursery raising practices

Area of nursery required for 1 ha	1000 sq m for dry nursery and wet nursery and 100 sq m for MMN (modified mat nursery) in SRI		
Nursery raising method	Dry nursery, wet nursery, SRI		
Bed size (length x breadth in m)	4-5 cm height and 1-1.5 m in width for dry nursery, keep saturatred for few days with water in wet nursery and 4 m wide bed in MMN.		
Seed sowing rate/m^2	2.5-3.0 in dry, 40-50 in wet and 10 kg/ha in modified SRI		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed**	**Method of application**
	Azospirillum	2 kg/ha	Rot dipping
	Phosphate solubilizers		2 kg/ha
Source and optimum quantity of organic manures/nutrient source/m^2 of nursery	**Materials**	**Quantity/m^2 area**	**Method of application**
	Vermicompost	2 kg Vermicompost	
Irrigation practices			
Weed management	Manual weeding		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/ m^2 area**
	Seed borne diseases	Solar seed treatment	

	Soil borne diseases	Seed and seedling treatment with tricoderma
Optimum age of nursery (days)	8-14 days in SRI	

Cultural practices

Seed rate (kg/ha)	60-100 kg/ha for upland condition		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate (kg/ha or lit/ha)**	**Method of application**
	Azosprillum and phosphate solubilizers	2 kg/ha	Seed treatment and seedling root dipping
	Azolla	500 kg/ ha	Azolla is incorporated as green manure before transplanting
Spacing (row × plant) in cm	20 × 15		
Number of seedling/hill	2-3		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	15 tonnes	
	Neem cake	1.0 tonnes	
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material/ practices used for control**	
	Diseases: Blast, Brown spot, Sheath rot, Sheath blight, Stem rot, False smut, Bacterial leaf blight and Tungro virus	Deep summer ploughing. Growing tolerant varieties. Crop rotation with oil seeds and pulses. Application of neem cake @ 150 kg/ha as basal dose. Spraying neem oil. Settig up of light traps. Spray blitox 0.3% at boot	

		leaf stage and 50 % at flowering stage.
	Insect pests: Stem borers, Leaf-folder (*Cnephalocrocis medinalis*), Gundhi-bug (*leptocorisca orientalis*), Rice-thrips (*Baliothrips biformis),* Rodents	Field sanitation, Placement of branches of *Chromoleana odoratum, Schima wallichi, Artemisia vulgaris in the field for repelling of insects.* Spraying of neem oil 0.03 EC @ 3 ml/l at 10 DAT

Rabi/summer crops under rice based sequences in irrigated condition

Cultural practices	**Vegetable pea**	**Fenugreek**	**Maize green cobs**	**Baby corn**	**Sunflower**	**Dhaincha**
Land preparation	Zero-tillage	2-3 ploughing One tilling	2-3 deep ploughing + 1 tilling	2-3 ploughing+ 1 tilling	2-3 ploughing +1 tilling	One ploughing
Organic manure application	Vermi-compost @ 1.0 t/ha	FYM @10 t/ha or vermi-compost 2 t/ha+ neem cake 0.5 t/ha	Mixed compost @ 5 t/ha + vermi-compost @ 1.0 t/ha + neem cake @ 1.0 t/ha + dolomite 1.0 t/ha should be applied	FMY @ 10 t+ Vermi-compost @ 2 t/ha	FYM @ 5 t/ha+ 1 t Poultry Manure+ 2 t Vermi-compost/ ha	NA
Time of sowing	November	November	February	February	November	May
Varieties	Kashi Udai	Sugandh	HQPM-9	VL-42	DRSH-108	local
Seed rate	100 kg/ha	40 kg seed/ha	25 kg seed/ha	25 kg/ha	4 kg/ha	45 kg/ha

Spacing	30 cm x 10 cm	20 cm x 10 cm	50 cm x 20 cm	45 cm x 15 cm	60 cm x 30 cm	Broad casting
Water management	First 45 DAS and second at pod filling stage	Irrigation has been given at 10 day interval and just after each cutting	At knee high stage	15-20 DAS and at just at appearance of silking	Three irrigations. 1. Bud initiation 2. Flower opening 3. Seed filling	One irrigation
Weed management	The critical period of crop weed competition is 40 days after sowing. One hand weeding, first at 30 DAS	Critical crop weed period 30 DAS First weeding	The critical period of crop weed competition is 45 days after sowing. One hand weeding at 15-20 DAS should be done to get the optimum yield. Use of weed biomass/ tree leaves' mulch between the rows is one of the best alternatives of hand weeding under organic weed management conditions.	Critical crop weed completion period 35 DAS One hand weeding at 20-30 das Weed biomass mulching @ 5 t/ha	Critical crop weed period 30-45 DAS One hand weeding at 30 DAS and mulching of farm litter @ 5 t/ha	NA
Harvesting	First picking 65-70 DAS	First cutting 60 DAS	110-115 days after sowing	First picking started 60 DAS	140 DAS	Incorporation in soil at 60 DAS

Vegetable cropping sequence for low cost plastic tunnels

1. Broccoli - spinach - coriander - broccoli - coriander

Crop	Nursery sowing	Sowing/ transplan-ting time	Varieties	Seed rate / ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Broccoli	First week of May	First week of June	Everest, Aishwarya, TSX-0788 *etc.*	600 - 700 g	FYM @ 1.5-2.0 kg/m^2, neem cake @ 200 g/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation	Planting should be in small pits.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 10-15 days interval.	Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600g
Spinach	-	Third week of September	All Green, Pusa Jyoti *etc.*	15 kg	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 7-10 days interval.	Three manual weeding at 10 days interval.	Leaf should be cut when attains marketable size or at 6-9" height plant should be uprooted.
Coriander	-	Third week of November	Pant Haritma, Super Midori, Khushboo, Rachna *etc.*	25-30 kg	FYM @ 1.5-2.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 7-10 days interval.	Three manual weeding at 10 days interval.	Harvesting should be done at 6-7" height and whole plant should be uprooted.
Broccoli	Second week of December	Third week of January	Everest, Aishwarya TSX-0788 *etc.*	600 - 700 g	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 15 days interval.	Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600g
Coriander	-	First week of May	Pant Haritma, Super Midori, Khushboo, Rachna *etc.*	25-30 kg		Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Two manual weeding at 7 days interval.	Harvesting should be done at 6-7" height and whole plant should be uprooted.

Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and spinach.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnants, stubble, debris *etc.* after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor of the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 litre + 2 litre + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/litre and second spray at 15 days interval. Spraying of *Bacillus thuringiensis* @ 2 g/litre checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Broccoli

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Plant cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2).
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Sanitize tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 g/kg of seeds.

- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Wiry stem/Damping off (*Rhizoctonia solani*)

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)

- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz*., COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.

Spinach: Major diseases have not been reported in spinach under Sikkim conditions.

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/litre.
- Spray neem seed kernel extract @ 5 per cent.

2. Broccoli - coriander - cabbage - radish - coriander

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Broccoli	First week of May	First week of June	Everest, Aishwarya, TSX-0788, *etc.*	600 - 700 g	FYM @ 1.5-2.0 kg/m^2, neem cake @ 200 g/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation	Planting should be in small pits.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 10-15 days interval.	Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g
Coriander	-	Third week of September	Pant Haritma, Super Midori, Khushboo, Rachna *etc*.	25-30 kg	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 7-10 days interval.	Three manual weeding at 10 days interval.	Harvesting should be done at 6-7" height and whole plant should be uprooted.
Cabbage	First week of October	Third week of November	Rare Ball, Magic Ball, BC-76, Golden Acre, Pragati *etc*.	500 - 600 g	FYM @ 1.5-2.0 kg/m^2 at the time of bed preparation	Planting should be in small pits.	40 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 15 days interval.	Harvesting should be done when head size: 15-20 cm diameter and weight: 1-1.5 kg
Radish	-	First week of March	Pusa Chetki, Chinese Pink *etc.*	8-10 kg	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	20 cm row to row, 5 cm plant to plant	Manual irrigation at 10 days interval.	Three manual weeding at 10 days interval.	Light irrigation may be given to facilitate lifting of roots.
Coriander	-	First week of May	Pant Haritma, Super Midori, Khushboo, Rachna *etc*.	25-30 kg		Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Two manual weeding at 7 days interval.	Harvesting should be done at 6-7" height and whole plant should be uprooted.

Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and radish.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli and cabbage.
- Remove and destroy all the remnants, stubble, debris *etc.* after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval.
- Spraying *Bacillus thuringiensis* @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Broccoli and cabbage

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and remove infected plants.
- Plant cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2).
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices since the spores are easily transported through water or wind.
- Sanitize tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).

- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Wiry stem/Damping off (*Rhizoctonia solani*)

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)

- Use certified seeds.
- Hot water treatment of seeds at 50^{o}C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.
- Use resistant varieties of cabbage like Cabaret, Defender, Gladiator, Pusa Mukta.

Radish: Major diseases have not been reported under Sikkim conditions.

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.

3. Coriander - radish - fenugreek - spinach - coriander

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Coriander	-	First week of June	Pant Haritma, Super Midori, Khushboo, Rachna *etc.*	25-30 kg	Vermicompost @ 0.5-1.0 kg/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation.	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Two manual weeding at 7 days interval.	Harvesting should be done at 6-7'' height and whole plant should be uprooted.
Radish	-	Third week of July	Pusa Chetki, Chinese Pink *etc.*	8-10 kg	FYM @ 1.5-2.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	20 cm row to row, 5 cm plant to plant	Manual irrigation at 10 days interval.	Three manual weeding at 10 days interval.	Light irrigation may be given to facilitate harvest of roots.
Fenugreek	-	First week of October	Local, Pusa Kasuri, Prabha, Sag Kalmi *etc.*	30-35 kg		Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Three manual weeding at 10 days interval.	Harvesting should be done at 6-7'' height and whole plant should be uprooted.
Spinach	-	First week of January	All Green, Pusa Jyoti *etc.*	15 kg	FYM @ 1.5-2.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 7-10 days interval.	Three manual weeding at 10 days interval.	Leaf should be cut when attains marketable size or at 6-9'' height plant should be uprooted.
Coriander	-	First week of April	Pant Haritma, Super Midori, Khushboo, Rachna	25-30 kg	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Two manual weeding at 7 days interval.	Harvesting should be done at 6-7'' height and whole plant should be uprooted.

Crop protection

Insect pests management: Insect pests that cause economic damage have not been reported under Sikkim conditions.

Disease management

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/litre.
- Spray neem seed kernel extract @ 5 per cent.

Fenugreek

Powdery mildew (*Erysiphe polygoni* and *Leveillula taurica*)

- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.

Radish: Major diseases have not been reported under Sikkim conditions.

Spinach: Major diseases have not been reported under Sikkim conditions.

4. Cabbage - Raya sâg - broccoli - coriander

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Cabbage	First week of May	First week of June	Golden Acre, Rare Ball, Magic Ball, BC-76, Pragati *etc.*	500 - 600 g	FYM @ 1.5 -2.0 kg/m^2, neem cake @ 200 g/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation	Planting should be in small pits.	40 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 10-15 days interval.	Harvesting should be done when head size: 15-20 cm diameter and weight: 1-1.5 kg
Raya sāg	Fourth week of August	Fourth week of September	Green leaf or purple leaf type	600 - 700 g	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation	Planting should be in small pits.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval.	Three manual weeding at 10 days interval.	Multiple leaf cut should be taken when attains marketable size or at 9-12" length.
Broccoli	Fourth week of November	First week of January	Everest, Aishwarya, TSX-0788, *etc.*	600 - 700 g	FYM @ 1.5 -2.0 kg/m^2, neem cake @ 200 g/m^2 at the time of bed preparation	Sowing should be in rows.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 15 days interval.	Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g
Coriander	-	Fourth week of April	Pant Haritma, Super Midori, Khushboo, Rachna	25-30 kg		Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Two manual weeding at 7 days interval.	Harvesting should be done at 6-7" height and whole plant should be uprooted.

Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and Raya sâg.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of cabbage and broccoli.
- Remove and destroy all the remnants, stubble, debris *etc*. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 litre + 2 litre + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/litre and second spray at 15 days interval.
- Spraying *Bacillus thuringiensis* @ 2 g/litre checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Cabbage and Broccoli

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Plant cabbage and other susceptible cruciferous crops in well drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.

- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Wiry stem/Damping off (*Rhizoctonia solani*)

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)

- Use certified seeds.
- Hot water treatment of seeds at 50^{o}C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz*., COC @ 0.25%.
- Provide drainage and free air movement to dry the moisture present on the plants.

- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.
- Use resistant varieties of cabbage *viz*., Cabaret, Defender, Gladiator, Pusa Mukta.

Raya sag

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Plant cabbage and other susceptible cruciferous crops in well drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.

5. Cabbage - spinach - broccoli - coriander

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Cabbage	First week of May	First week of June	Golden Acre, Rare Ball, Magic Ball, BC-76, Pragati *etc.*	500 - 600 g	FYM @ 1.5 -2.0 kg/m^2, neem cake @ 200 g/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation	Planting should be in small pits.	40 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 10-15 days interval.	Harvesting should be done when head size: 15-20 cm diameter and weight: 1-1.5 kg
Spinach	-	Fourth week of September	All Green, Pusa Jyoti *etc.*	15 kg	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 7-10 days interval.	Three manual weeding at 10 days interval.	Leaf should be cut when attains marketable size or at 6-9" height plant should be uprooted.
Broccoli	First week of November	Second week of December	Everest, Aishwarya, TSX-0788, *etc.*	600 - 700 g	FYM @ 1.5 -2.0 kg/m^2, neem cake @ 200 g/m^2 at the time of bed preparation	Planting should be in small pits.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 15 days interval.	Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g
Coriander	-	Second week of April	Pant Haritma, Super Midori, Khushboo, Rachna	25-30 kg		Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Two manual weeding at 7 days interval.	Harvesting should be done at 6-7" height and whole plant should be uprooted.

Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and spinach.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnants, stubble, debris *etc*. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 litre + 2 litre + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/litre and second spray at 15 days interval. Spraying of *Bacillus thuringiensis* @ 2 g/litre checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Cabbage and broccoli

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Plant cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 g/kg of seeds.

- Drench with copper oxycholoride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Wiry stem/Damping off (*Rhizoctonia solani*)

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)

- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.

Spinach: Major diseases have not been reported in spinach under Sikkim conditions.

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/litre.
- Spray neem seed kernel extract @ 5 per cent.

6. Coriander - radish - fenugreek - cauliflower - pakchoi

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Coriander	-	First week of June	Pant Haritma, Super Midori, Khushboo, Rachna	25 - 30 kg	Vermicompost @ 0.5-1.0 kg/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Two manual weeding at 7 days interval.	Harvesting should be done at 6-7" height and whole plant should be uprooted.
Radish	-	Second week of July	Pusa Chetki, Chinese Pink *etc.*	8-10 kg	FYM @ 1.5 -2.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	20 cm row to row, 5 cm plant to plant	Manual irrigation at 10 days interval.	Three manual weeding at 10 days interval.	Light irrigation may be given before harvesting to facilitate harvesting of roots.
Fenugreek	-	Fourth week of September	Local, Pusa Kasuri, Prabha, Sag Kalmi *etc.*	30 - 35 kg		Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Three manual weeding at 10 days interval.	Harvesting should be done at 6-7" height and whole plant should be uprooted.
Cauliflower	First week of November	First week of December	Suhasini, Snow Ball, Sumedha, Shalakha, Pusa Katki *etc.*	400 - 500 g	FYM @ 1.5 -2.0 kg/m^2, neem cake @ 200 g/m^2 at the time of bed preparation.	Planting should be in small pits.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 15 days interval.	Harvest curd at compact stage. Approx. head size: 15-20 cm diameter, weight: 500 g to 1.0 kg
Pakchoi	First week of March	First week of April	Shuko	400 - 500 g	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation.	Planting should be in small pits.	30 cm row to row, 30 cm plant to plant	Manual irrigation at 10 days interval.	Three manual weeding at 10 days interval.	Harvesting should be done at 6-8" height and whole plant should be uprooted.

Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and spinach.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnants, stubble, debris *etc*. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 litre + 2 litre + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/litre and second spray at 15 days interval. Spraying of *Bacillus thuringiensis* @ 2 g/litre checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/litre.

- Spray neem seed kernel extract @ 5 per cent.

Radish: Major diseases have not been found under Sikkim conditions.

Fenugreek

Powdery mildew (*Erysiphe polygoni* and *Leveillula taurica*)

- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.

Cauliflower and Pakchoi

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Planting cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 g/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.

- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Wiry stem/Damping off (*Rhizoctonia solani*)

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)

- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.

Vegetable cropping sequence for low cost plastic rain shelter

1. Tomato - tomato - pea

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Tomato	First week of March	First week of April	Pusa Ruby, Punjab Chuhara, Romeo, Jessica, Epoch. Lakshman, Megha Tomato-2, Megha Tomato-3, *etc.*	400 - 500 g	FYM @ 4-5 kg/m^2, neem cake @ 200 g/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation. Seedling root dip with *Azospirillum* + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m^2 after two months of transplanting.	Planting should be in small pits.	75 cm row to row, 60 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.	Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.
Tomato	Last week of June	Last week of July	Pusa Ruby, Punjab Chuhara, Romeo, Jessica, Epoch. Lakshman, Megha Tomato-2, Megha Tomato-3, *etc.*	400 - 500 g	FYM @ 4-5 kg/m^2, neem cake @ 200 g/m^2 at the time of bed preparation. Seedling root dip with *Azospirillum* + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m^2 after two months of transplanting.	Planting should be in small pits.	75 cm row to row, 60 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.	Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.
Pea	-	Third week of November	TSX-10, Pant Sabzi Matar-3 Pusa Pragati, VRP-5, VRP-6, Dentame *etc.*	100 - 125 kg	FYM @ 1.5-2.0 kg/m^2 at the time of bed preparation.	Sowing should be done in rows either on ridges, furrows or flat land.	30 cm x 30 cm and for Dentame 45 cm row to row, 30 cm plant to plant.	Soil kept moist till germination and then irrigate at flowering and pod filling stage.	Three manual weeding at 10-15 days interval.	Multiple harvest of mature green pods with pedicel and minimum disturbance to the plants.

Crop protection

Insect pests management

- White fly, aphids and fruit borer cause economic damage in tomato.
- Use petroleum-oil based agro spray @ 10 ml/litre and second spray at 20 days interval to control whitefly and aphids in tomato and aphids in pea.
- Regularly monitor, collect and destroy larvae for controlling fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/litre and second spray at 20 days interval is effective to control of tomato fruit borer and pod borer in pea.
- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.

Disease management

Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

Early blight (*Alternaria solani*)

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.

- When the foliage is wet working in the field should be avoided.
- Use resistant varieties like Arka Rakshak, Arka Samrat.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

Late blight (*Phytophthora infestans*)

- Remove infected plant debris after harvest.
- Crop rotation with non-solanaceaous crops.
- Provide sufficient drainage.
- Maintain optimum spacing to allow free air circulation.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

Bacterial wilt (*Pseudomonas solanacearum*)

- Field sanitation and remove infected plants immediately after the appearance of the symptom.
- Crop rotation with non-solanaceous crops.
- Spray copper fungicide Bordeaux mixture @ 1% (10 g $CuSO_4$ + 10 g lime + 1 litre water) or COC @ 0.25 per cent.
- Raise soil pH with dolomite application @ 200 gm/m^2 and increase the calcium content in the soil.
- Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.
- Apply plant resistance inducer.
- Incorporate *Brassica* spp. at flowering stage as manure.
- Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 litre of water) to drench the soil 3 times *i.e.*, at 15, 30 and 45 days after transplanting.
- Flood the field one or two weeks before planting.
- Control root knot nematode to avoid plant injury.
- Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.
- Use resistant varieties *viz.*, Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Arka Alok, Arka Abha, Swaraksha, NS-52, 53, 537, 247, 501, 4032, VT-1, 4.

Tomato mosaic virus

- Use disease-free seeds.
- Avoid smoking in the field.
- Wash hands with soap and water before and after handling infected plants.
- Avoid the soil in which the previous crop was infected.

Tomato leaf curl (*Tomato leaf curl virus*)

- Remove and destroy infected plants.
- Use yellow sticky traps to monitor and control white flies.
- Apply petroleum oil-based agro spray @ 7 ml/litre.
- Remove alternate or collateral hosts.
- Use resistant varieties *viz*., Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Kashi Amrit, Shaktiman, Ananya, Vaibhav, Uttam, NS-510, 524, 534.

Tomato spotted wilt virus

- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew

- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Pea

Wilt and Root rot (*Fusarium oxysporum* and *Rhizoctonia solani*)

- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.

- Use resistant varieties *viz*., JP Batri Brown-3 and JP Batri Brown-4.
- Drench soil with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

Powdery mildew (*Erysiphe polygoni*)

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.
- Varieties maturing in January usually escape the maximum intensity of the disease.
- Dusting sulphur @ 25 kg/ha is also recommended.
- Use resistant varieties *viz*., Pusa Pragati, Pusa Prabhat (DDR-23), Pusa Panna (DDR-27), Arka Ajit, Arka Karthik and Arka Sampoorna, Pant Sabji Matar-4, Pant Sabji Matar-5, Azad P-2, Azad P-4, Azad P-5.

Rust (*Uromyces fabae*)

- The affected plant trash should be burnt after harvest.
- Follow suitable crop-rotation with non-leguminous crops.
- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.
- Early sowing in the month of October.
- Use resistant varieties *viz*., Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.

2. Bitter gourd/Sponge gourd/Bottle gourd - tomato - pea

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Bitter gourd/ Sponge gourd/ Bottle gourd	First week of March	Transplanting first week of April or direct sown in April.	**Bitter gourd:** Pusa Vishesh, Arka Harit, Sapan *etc.* **Sponge gourd:** Pusa Chikni, Pusa Nasdar, Aneeta *etc.* **Bottle gourd:** Pusa Summer Prolific Long, Pusa Naveen, Pusa Meghdut, Pusa Summer Prolific Round *etc.*	4-5 kg for all the crops	Vermicompost @ 0.5-1.0 kg/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation.	Planting / sowing should be in small pits.	**Bitter gourd**: 150 cm x 100 cm **Sponge gourd**: 150 cm x 100 cm **Bottle gourd**: 200 cm x 150 cm	Manual irrigation at 3-5 days interval for initial establishment of seedlings or soil is kept moist till germination for direct sowing. Later, irrigate at 10-15 days interval or by drip irrigation.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking should be done with bamboo sticks and light pruning should be carried out to remove excessive growth.	Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully from the vine without uprooting or injuring them.
Tomato	Last week of June	Last week of July	Pusa Ruby, Punjab Chuhara, Romeo, Jessica, Epoch, Lakshman, Megha Tomato-2, Megha Tomato-3, *etc.*	400 - 500 g	FYM @ 4-5 kg/m^2, neem cake @ 200 g/m^2 at the time of bed preparation. Seedling root dip with *Azospirillum* + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m^2 after two months of transplanting.	Planting should be in small pits.	75 cm row to row, 60 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.	Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.
Pea	-	Third week of November	TSX-10, Pant Sabzi Matar-3 Pusa Pragati, VRP-5, VRP-6, Dentame *etc*.	100 - 125 kg	FYM @ 1.5 - 2.0 kg/m^2 at the time of bed preparation.	Sowing should be done in rows either on ridges, furrows or flat land.	30 cm x 30 cm for Dentame; Others 45 cm row to row, 30 cm plant to plant.	Soil kept moist till germination and then irrigate at flowering and pod filling stage.	Three manual weeding at 10-15 days interval.	Multiple harvesting of mature green pods with pedicel and minimum disturbance to the plants.

Crop protection

Insect pests management

- Fruit fly is the major problem in cucurbits like bottle gourd, sponge gourd, bitter gourd *etc*.
- Collect fallen infested fruits and destroy the maggots that remain inside fruits for management of fruit fly.
- Install methyl eugenol based para-pheromone traps @ 16-20 traps/ha.
- White fly, aphids and fruit borer cause economic damage in tomato.
- Use petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato and aphids in pea.
- Regularly monitor, collect and destroy larvae to control fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer and pod borer in pea.
- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.

Disease management

Bitter gourd, Sponge gourd and Bottle gourd

Powdery mildew (*Podosphaera xanthii* and *Erysiphe cichoracearum*)

- Grow resistant varieties when available (cucumber, muskmelon, and pumpkin).
- Spray wettable sulphur @ 0.25 per cent or neem oil @ 3 per cent or petroleum oil-based agro spray @ 0.7 per cent at the very appearance of the disease.
- Bottle gourd variety, N. Shishir (NDBG-202) is resistant to powdery mildew.

Downy mildew (*Pseudoperonospora cubensis*)

- Use resistant cultivars when possible (primarily, cucumber).

- Overhead irrigation should be avoided.
- Preventive spraying with copper oxychloride @ 0.25 per cent.
- Planting early may help to avoid conditions conducive to the disease later in the season.
- Use of bed system with wide spacing with good drainage and air movement and exposure to sun helps to check disease development.
- Bottle gourd variety, N. Shishir (NDBG-202) is resistant to Downy mildew.
- Bitter gourd variety, Phule Green Gold tolerant to Downy mildew.

Choanephora wet rot (*Choanephora cucurbitarum*)

- Plant on raised beds.
- Fruit injury should be prevented.
- Plastic mulches or trellising should be done to avoid direct contact of fruits with soil.
- Harvest fruits at proper stage of maturity.

Fruit rot (*Pythium aphanidermatum*)

- Drench soil with copper oxychloride @ 0.25 per cent.
- Fruits should be kept away from soil.

Anthracnose (*Colletotrichum orbiculare*)

- Sow pathogen-free seed of resistant varieties.
- Crop rotations with unrelated crops for at least two years.
- Good sanitation practices, such as cleaning up crop debris at the end of the growing season should be followed.
- Avoid overhead irrigation.
- Spray copper oxychloride @ 0.25 per cent.
- Bottle gourd variety, N. Shishir (NDBG-202) is resistant to anthracnose.

Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

Early blight (*Alternaria solani*)

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.
- When the foliage is wet working in the field should be avoided.
- Use resistant varieties like Arka Rakshak, Arka Samrat.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

Late blight (*Phytophthora infestans*)

- Remove infected plant debris after harvest.
- Crop rotation with non-solanaceaous crops.

- Provide sufficient drainage.
- Maintain optimum spacing to allow free air circulation.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

Bacterial wilt (*Pseudomonas solanacearum*)

- Field sanitation and remove infected plants immediately after the appearance of the symptom.
- Crop rotation with non-solanaceous crops.
- Spray copper fungicide Bordeaux mixture @ 1% (10 g $CuSO_4$ + 10 g lime + 1 l water) or COC @ 0.25 per cent.
- Raise soil pH with dolomite application @ 200 gm/m^2 and increase the calcium content in the soil.
- Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.
- Apply plant resistance inducer.
- Incorporate *Brassica* spp. at flowering stage as manure.
- Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 l of water) to drench the soil 3 times *i.e.*, at 15, 30 and 45 days after transplanting.
- Flood the field one or two weeks before planting.
- Control root knot nematode to avoid plant injury.
- Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.
- Use resistant varieties *viz.*, Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Arka Alok, Arka Abha, Swaraksha, NS-52, 53, 537, 247, 501, 4032, VT-1, 4.

Tomato mosaic virus

- Use disease-free seeds.
- Avoid smoking in the field.

- Wash hands with soap and water before and after handling infected plants.
- Avoid the soil in which the previous crop was infected.

Tomato leaf curl (*Tomato leaf curl virus*)

- Remove and destroy infected plants.
- Use yellow sticky traps to monitor and control white flies.
- Apply petroleum oil-based agro spray @ 7 ml/l.
- Remove alternate or collateral hosts.
- Use resistant varieties *viz*., Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Kashi Amrit, Shaktiman, Ananya, Vaibhav, Uttam, NS-510, 524, 534.

Tomato spotted wilt virus

- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew

- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Pea

Wilt and Root rot (*Fusarium oxysporum* and *Rhizoctonia solani*)

- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.

- Use resistant varieties *viz*., JP Batri Brown-3 and JP Batri Brown-4.
- Drench soil with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

Powdery mildew (*Erysiphe polygoni*)

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.
- Varieties maturing in January usually escape the maximum intensity of the disease.
- Dusting sulphur @ 25 kg/ha is also recommended.
- Use resistant varieties *viz*., Pusa Pragati, Pusa Prabhat (DDR-23), Pusa Panna (DDR-27) Arka Ajit, Arka Karthik and Arka Sampoorna, Pant Sabji Matar-4, Pant Sabji Matar-5, Azad P-2, Azad P-4, Azad P-5.

Rust (*Uromyces fabae*)

- The affected plant trash should be burnt after harvest.
- Follow suitable crop-rotation with non-leguminous crops.
- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.
- Early sowing in the month of October.
- Use resistant varieties *viz*., Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.

3. Bitter gourd/Sponge gourd/Bottle gourd - capsicum - pea

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Bitter gourd/ Sponge gourd/ Bottle gourd	First week of March	Transplanting first week of April or direct sown in April.	**Bitter gourd:** Pusa Vishesh, Arka Harit, Sapan *etc.* **Sponge gourd:** Pusa Chikni, Pusa Nasdar, Aneeta *etc.* **Bottle gourd:** Pusa Summer Prolific Long, Pusa Naveen, Pusa Meghdut, Pusa Summer Prolific Round *etc.*	4-5 kg for all the crops	Vermicompost @ 0.5-1.0 kg/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation.	Planting / sowing should be in small pits.	**Bitter gourd**: 150 cm x 100 cm **Sponge gourd**: 150 cm x 100 cm **Bottle gourd**: 200 cm x 150 cm	Manual irrigation at 3-5 days interval for initial establishment of seedlings or soil is kept moist till germination for direct sowing. Later irrigate at 10-15 days interval or by drip irrigation.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking should be done with bamboo sticks and light pruning should be carried out to remove excessive growth.	Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully from the vine without uprooting or injuring them.
Capsicum	Last week of June	Last week of July	California Wonder, Pusa Deepti, Bharat, Indra, Orebelle, Green Gold *etc.*	1.0 - 1.5 kg	FYM @ 1.5 -2.0 kg/m^2 at the time of bed preparation and vermicompost @ 0.5-1.0 kg/m^2 60 days after transplanting.	Planting should be in small pits.	60 cm row to row, 50 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings. Later irrigate at 15-20 days interval or by drip irrigation.	Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use.	Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully without damaging the plant.
Pea	-	Third week of November	TSX-10, Pant Sabzi Matar-3 Pusa Pragati, VRP-5, VRP-6, Dentame *etc.*	100 - 125 kg	FYM @ 1.5 -2.0 kg/m^2 at the time of bed preparation.	Sowing should be done in rows either on ridges, furrows or flat land.	Dentame 45 cm row to row, 30 cm plant to plant. Others 30 cm x30 cm	Soil kept moist till germination and then irrigate at flowering and pod filling stage.	Three manual weeding at 10-15 days interval.	Multiple harvesting of mature green pods with pedicel and minimum disturbance to the plants.

Crop protection

Insect pests management

- Fruit fly is the major problem in cucurbits like bottle gourd, sponge gourd, bitter gourd *etc*.
- Collect fallen infested fruits and destroy the maggots that remain inside fruits for management of fruit fly.
- Install methyl eugenol based para-pheromone traps @ 16-20 traps/ha.
- White fly, aphids and fruit borer cause economic damage in tomato.
- Apply petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato and aphids in pea.
- Regularly monitor, collect and destroy larvae for controlling fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control tomato fruit borer and pod borer in pea.
- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.

Disease management

Bitter gourd, Sponge gourd and Bottle gourd

Powdery mildew (*Podosphaera xanthii* and *Erysiphe cichoracearum*)

- Grow resistant varieties when available (cucumber, muskmelon, and pumpkin).
- Spray wettable sulphur @ 0.25 per cent or neem oil @ 3 per cent or petroleum oil-based agro spray @ 0.7 per cent at the very appearance of the disease.
- Bottle gourd variety, N. Shishir (NDBG-202) is resistant to powdery mildew.

Downy mildew (*Pseudoperonospora cubensis*)

- Use resistant cultivars when possible (primarily, cucumber).
- Overhead irrigation should be avoided.

- Preventive spraying with copper oxychloride @ 0.25 per cent.
- Planting early may help to avoid conditions conducive to the disease later in the season.
- Use of bed system with wide spacing with good drainage and air movement and exposure to sun helps to check disease development.
- Bottle gourd variety, N. Shishir (NDBG-202) is resistant to Downy mildew.
- Bitter gourd variety, Phule Green Gold tolerant to Downy mildew

Choanephora wet rot (*Choanephora cucurbitarum*)

- Plant on raised beds.
- Fruit injury should be prevented.
- Plastic mulches or trellising should be done to avoid direct contact of fruits with soil.
- Harvest fruits at proper stage of maturity.

Fruit rot (*Pythium aphanidermatum*)

- Drench soil with copper oxychloride @ 0.25 per cent.
- Fruits should be kept away from soil.

Anthracnose (*Colletotrichum orbiculare*)

- Sow pathogen-free seed of resistant varieties.
- Crop rotations with unrelated crops for at least two years.
- Good sanitation practices, such as cleaning up crop debris at the end of the growing season should be followed.
- Avoid overhead irrigation.
- Spray copper oxychloride @ 0.25 per cent.
- Bottle gourd variety, N. Shishir (NDBG-202) is resistant to anthracnose.

Capsicum

Anthracnose (*Colletotrichum capsici*)

- Use disease-free seeds.
- Collect and destroy infected plant debris.
- Apply Bordeaux mixture @ 1 per cent at 20 days interval commencing from one month after transplanting.
- Spray copper oxychloride @ 2.5 per cent thrice at 15 days interval starting from observing the die-back symptoms.
- Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 2 per cent.
- Use of plant extracts like sweet flag, tulsi and neem oil are reported to control the disease.

Cercospora leaf spot (*Cercospora capsici*)

- Remove and burn crop debris.
- Spray copper oxychloride @ 0.25 per cent.
- Adequate spacing should be given to avoid leaf wetness and improve air circulation.

Damping off (*Pythium* spp.)

- Destroy plant debris after harvest.
- Sowing seed on raised beds of 6-8" high (15 cm).
- Use low seed rate of 650 g/cent.
- Crop rotation with non-host crops like mustard.
- Apply well-decomposed FYM.
- Treat nursery soil with *Trichoderma viride* @ 2 per cent.
- Seed treatment with *Trichoderma viride* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed 24 hours before sowing.

- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM.
- Water stagnation should be avoided
- Drench with copper oxychloride @ 2.5 g/lit or Bordeaux mixture @ 1 per cent.

Phytophthora blight (*Phytophthora capcisi*)

- Poorly-drained soil and excess watering should be avoided.
- Mulch the soil to avoid direct contact of fruits with soil.
- Overhead irrigation should be avoided.
- Remove and destroy the infected plant as soon as symptoms appears.
- Crop rotation with non-solanaceous crops like cereals, oilseeds and pulses.

Chilli mosaic (*Chilli mosaic virus*)

- Remove and destroy affected plants.
- Use virus-free seedlings.
- Growing barrier crops like maize (2-3 rows) around chillies to reduce the disease incidence.

Leaf curl (*Gemini virus*)

- Remove and destroy affected plants.
- Use neem oil or NSKE @ 0.3 per cent and @ 5 per cent, respectively to control aphids.

Pea

Wilt and Root rot (*Fusarium oxysporum* and *Rhizoctonia solani*)

- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.
- Use resistant varieties *viz.*, JP Batri Brown-3 and JP Batri Brown-4.

- Drench soil with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

Powdery mildew (*Erysiphe polygoni*)

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.
- Varieties maturing in January usually escape the maximum intensity of the disease.
- Dusting sulphur @ 25 kg/ha is also recommended.
- Use resistant varieties *viz*., Pusa Pragati, Pusa Prabhat (DDR-23), Pusa Panna (DDR-27) Arka Ajit, Arka Karthik and Arka Sampoorna, Pant Sabji Matar-4, Pant Sabji Matar-5, Azad P-2, Azad P-4, Azad P-5.

Rust (*Uromyces fabae*)

- The affected plant trash should be burnt after harvest.
- Follow suitable crop-rotation with non-leguminous crops.
- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.
- Early sowing in the month of October.
- Use resistant varieties *viz*., Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.

Vegetable cropping sequence for low cost polyhouse

1. Cucumber - tomato - cabbage (cole crops)

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Cucumber	-	First week of April	Sikkim local, Pusa Sanyog, Poinselle, Green Long *etc.*	3-4 kg	Vermicompost @ 0.5-1.0 kg/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation.	Sowing should be done in rows either on ridges or on raised bed.	150 cm row to row, 100 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation. Excessive watering should be avoided.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking should be done with bamboo sticks and light pruning should be done to remove excessive growth.	Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully from the vine without injuring them.
Tomato	Last week of June	Last week of July	All Rounder, Avinash, Naveen, Avatar, Megha Tomato-2, Megha Tomato-3, Lakshman *etc.*	400 - 500 g	FYM @ 4-5 kg/m^2 and neem cake @ 200 g/m^2 at the time of bed preparation. Seedling root dip with *Azospirillum* + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m^2 after two months of transplanting.	Planting should be done in rows on raised bed.	100 cm row to row, 75 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.	Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.
Cabbage	Second week of October	Third week of November	Rare Ball, Magic Ball, BC-76, Golden Acre, Pragati *etc.*	500 - 600 g	FYM @ 1.5-2.0 kg/m^2 and neem cake @ 200 g/m^2 at the time of bed preparation.	Planting should be done in small pits in rows.	40 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 15 days interval.	Harvesting should be done when head size: 15-20 cm diameter and weight: 1-1.5 kg

Crop protection

Insect pests management

- Fruit fly is the major problem in cucumber.
- Collect fallen infested fruits and destroy the maggots that remain inside the fruits for management of fruit fly.
- Install methyl eugenol based para-pheromone traps @ 16-20 traps/ha.
- White fly, aphids and fruit borer cause economic damage in tomato. Use petroleum-oil based ago spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato.
- Regularly monitor, collect and destroy the larvae for controlling fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer.
- Installing pheromone trap for mass trapping adult of fruit borers is highly effective.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnant stubble, debris *etc*. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 litre + 2 litre + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/litre and second spray at 15 days interval. Spraying of *Bacillus thuringiensis* @ 2 g/litre checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Cucumber

Fruit rot (*Pythium aphanidermatum*)

- Drench soil with copper oxychloride @ 0.25 per cent.
- Fruits should be kept away from soil.

Anthracnose (*Colletotrichum orbiculare*)

- Use pathogen-free seed of resistant varieties.
- Crop rotations with unrelated crops for at least 2 years.
- Good sanitation practices, such as cleaning up crop debris at the end of the growing season should be followed.
- Avoid overhead irrigation.
- Spray copper oxychloride @ 0.25 per cent.

Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

Early blight (*Alternaria solani*)

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.

- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.
- When the foliage is wet working in the field should be avoided.
- Use resistant varieties like Arka Rakshak, Arka Samrat.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

Late blight (*Phytophthora infestans*)

- Remove infected plant debris after harvest.
- Crop rotation with non-solanaceaous crops.
- Provide sufficient drainage.
- Maintain optimum spacing to allow free air circulation.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

Bacterial wilt (*Pseudomonas solanacearum*)

- Field sanitation and remove infected plants immediately after the appearance of the symptom.
- Crop rotation with non-solanaceous crops.
- Spray copper fungicide Bordeaux mixture @ 1% (10 g $CuSO_4$ + 10 g lime + 1 litre water) or COC @ 0.25 per cent.
- Raise soil pH with dolomite application @ 200 gm/m^2 and increase the calcium content in the soil.

- Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.
- Apply plant resistance inducer.
- Incorporate *Brassica* spp. at flowering stage as manure.
- Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 litre of water) to drench the soil 3 times *i.e.*, at 15, 30 and 45 days after transplanting.
- Flood the field one or two weeks before planting.
- Control root knot nematode to avoid plant injury.
- Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.
- Use resistant varieties *viz*., Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Arka Alok, Arka Abha, Swaraksha, NS-52, 53, 537, 247, 501, 4032, VT-1, 4.

Tomato mosaic virus

- Use disease-free seeds.
- Avoid smoking in the field.
- Wash hands with soap and water before and after handling infected plants.
- Avoid the soil in which the previous crop was infected.

Tomato leaf curl (*Tomato leaf curl virus*)

- Remove and destroy infected plants.
- Use yellow sticky traps to monitor and control white flies.
- Apply petroleum oil-based agro spray @ 7 ml/litre.
- Remove alternate or collateral hosts.
- Use resistant varieties *viz*., Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Kashi Amrit, Shaktiman, Ananya, Vaibhav, Uttam, NS-510, 524, 534.

Tomato spotted wilt virus

- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew (*Erysiphe polygoni*)

- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Cabbage

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and remove infected plants.
- Planting cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).

- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drenching with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Wiry stem/Damping off (*Rhizoctonia solani*)

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)

- Use certified seeds.
- Hot water treatment of seeds at 50^{o}C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.

2. Capsicum - tomato - broccoli (cole crops)

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Capsicum	First week of March	First week of April	California Wonder, Pusa Deepti, Bharat, Indra, Orebelle, Green Gold *etc*.	1.0-1.5 kg	FYM @ 1.5 -2.0 kg/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation and vermicompost @ 0.5-1.0 kg/m^2 60 days after transplanting.	Planting should be in rows in small pits.	60 cm row to row, 50 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings. Later, irrigate at 15-20 days interval or by drip irrigation.	Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use.	Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully without damaging the plant.
Tomato	Last week of June	Last week of July	All Rounder, Avinash, Naveen, Avatar, Megha Tomato-2, Megha Tomato-3, Lakshman *etc*.	400 - 500 g	FYM @ 4-5 kg/m^2, neem cake @ 200 g/m^2 at the time of bed preparation. Seedling root dip with *Azospirillum* + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m^2 after two months of transplanting.	Planting should be in small pits.	100 cm row to row, 75 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.	Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.
Broccoli	Second week of October	Third week of November	Everest, Aishwarya TSX-0788 *etc*.	600 - 700 g	FYM @ 1.5 -2.0 kg/m^2, neem cake @ 200 g/m^2 at the time of bed preparation	Planting should be in small pits.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 15 days interval.	Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g

Crop protection

Insect pests management

- White fly, aphids and fruit borer cause economic damage in tomato. Use petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato.
- Regularly monitor, collect and destroy larvae for fruit borer.
- Spray Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer.
- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnant stubble, debris *etc*. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 litre + 2 litre + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/litre and second spray at 15 days interval. Spraying of *Bacillus thuringiensis* @ 2 g/litre checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Capsicum

Anthracnose (*Colletotrichum capsici*)

- Use disease-free seeds.

- Collect and destroy infected plant debris.
- Apply Bordeaux mixture @ 1 per cent at 20 days interval commencing from one month after transplanting.
- Spray copper oxychloride @ 2.5 per cent thrice at 15 days interval starting from observing the die-back symptoms.
- Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 2 per cent.
- Use of plant extracts like sweet flag, tulsi and neem oil are reported to control the disease.

Cercospora leaf spot (*Cercospora capsici*)

- Remove and burn crop debris.
- Spray copper oxychloride @ 0.25 per cent.
- Adequate spacing should be given to avoid leaf wetness and improve air circulation.

Damping off (*Pythium* spp.)

- Destroy plant debris after harvest.
- Sowing seed on raised beds of 6-8" high (15 cm).
- Use low seed rate of 650 g/cent.
- Crop rotation with non-host crops like mustard.
- Apply well-decomposed FYM.
- Treat nursery soil with *Trichoderma viride* @ 2 per cent.
- Seed treatment with *Trichoderma viride* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed 24 hours before sowing.
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM.
- Water stagnation should be avoided
- Drench with copper oxychloride @ 2.5 g/lit or Bordeaux mixture @ 1 per cent.

Phytophthora blight (*Phytophthora capcisi*)

- Poorly-drained soil and excess watering should be avoided.
- Mulch the soil to avoid direct contact of fruits with soil.
- Overhead irrigation should be avoided.
- Remove and destroy the infected plant as soon as symptoms appears.
- Crop rotation with non-solanaceous crops like cereals, oilseeds and pulses.

Chilli mosaic (*Chilli mosaic virus*)

- Remove and destroy affected plants.
- Use virus-free seedlings.
- Growing barrier crops like maize (2-3 rows) around chillies to reduce the disease incidence.

Leaf curl (*Gemini virus*)

- Remove and destroy affected plants.
- Use neem oil or NSKE @ 0.3 per cent and @ 5 per cent, respectively to control aphids.

Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

Early blight (*Alternaria solani*)

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.

- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.
- When the foliage is wet working in the field should be avoided.
- Use resistant varieties like Arka Rakshak, Arka Samrat.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

Late blight (*Phytophthora infestans*)

- Remove infected plant debris after harvest.
- Crop rotation with non-solanaceaous crops.
- Provide sufficient drainage.
- Maintain optimum spacing to allow free air circulation.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

Bacterial wilt (*Pseudomonas solanacearum*)

- Field sanitation and remove infected plants immediately after the appearance of the symptom.
- Crop rotation with non-solanaceous crops.
- Spray copper fungicide Bordeaux mixture @ 1% (10 g $CuSO_4$ + 10 g lime + 1 litre water) or COC @ 0.25 per cent.

- Raise soil pH with dolomite application @ 200 gm/m^2 and increase the calcium content in the soil.
- Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.
- Apply plant resistance inducer.
- Incorporate *Brassica* spp. at flowering stage as manure.
- Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 litre of water) to drench the soil 3 times *i.e.*, at 15, 30 and 45 days after transplanting.
- Flood the field one or two weeks before planting.
- Control root knot nematode to avoid plant injury.
- Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.
- Use resistant varieties *viz.*, Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Arka Alok, Arka Abha, Swaraksha, NS-52, 53, 537, 247, 501, 4032, VT-1, 4.

Tomato mosaic virus

- Use disease-free seeds.
- Avoid smoking in the field.
- Wash hands with soap and water before and after handling infected plants.
- Avoid the soil in which the previous crop was infected.

Tomato leaf curl (*Tomato leaf curl virus*)

- Remove and destroy infected plants.
- Use yellow sticky traps to monitor and control white flies.
- Apply petroleum oil-based agro spray @ 7 ml/litre.
- Remove alternate or collateral hosts.
- Use resistant varieties *viz.*, Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Kashi Amrit, Shaktiman, Ananya, Vaibhav, Uttam, NS-510, 524, 534.

Tomato spotted wilt virus

- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew (*Erysiphe polygoni*)

- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Broccoli

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and remove infected plants.
- Planting cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).

- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Wiry stem/Damping off (*Rhizoctonia solani*)

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)

- Use certified seeds.
- Hot water treatment of seeds at 50^{o}C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.

3. Tomato - capsicum - cauliflower (cole crops)

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Tomato	First week of March	First week of April	All Rounder, Avinash, Naveen, Avatar, Megha Tomato-2, Megha Tomato-3, Lakshman *etc*.	400 - 500 g	FYM @ 4-5 kg/m^2, neem cake @ 200 g/m^2 and dolomite @ 200 g/m^2 at the time of bed preparation. Seedling root dip with *Azospirillum* + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m^2 after two months of transplanting.	Planting should be done in rows on raised bed.	100 cm row to row, 75 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.	Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.	Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.
Capsicum	Last week of June	Last week of July	California Wonder, Pusa Deepti, Bharat, Indra, Orebelle, Green Gold *etc*.	1.0 - 1.5 kg	FYM @ 1.5-2.0 kg/m^2 and neem cake @ 200 g/m^2 at the time of bed preparation and vermicompost @ 0.5-1.0 kg/m^2 60 days after transplanting.	Planting should be in rows in small pits.	60 cm row to row, 50 cm plant to plant.	Manual irrigation at 3-5 days interval for initial establishment of seedlings. Later irrigation at 15-20 days interval or by drip irrigation.	Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use.	Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully without damaging the plant.
Cauliflower	Second week of October	Third week of November	Suhasini, Snow Ball, Sumedha, Shalakha, Pusa Katki *etc*.	400 - 500 g	FYM @ 1.5-2.0 kg/m^2 and neem cake @ 200 g/m^2 at the time of bed preparation.	Planting should be in small pits.	45 cm row to row, 30 cm plant to plant	Manual irrigation at 10-15 days interval or by drip irrigation.	Three manual weeding at 15 days interval.	Harvest curd at compact stage. Approx. head size: 15-20 cm diameter, weight: 500 g to 1.0 kg

Crop protection

Insect pests management

- White fly, aphids and fruit borer cause economic damage in tomato. Use petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato.
- Regularly monitor, collect and destroy larvae for fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer.
- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnant stubble, debris *etc*. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 litre + 2 litre + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/litre and second spray at 15 days interval. Spraying of *Bacillus thuringiensis* @ 2 g/litre checks the population of cutworm, semi-looper and Diamond back moth

Disease management

Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.

- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

Early blight (*Alternaria solani*)

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.
- When the foliage is wet working in the field should be avoided.
- Use resistant varieties like Arka Rakshak, Arka Samrat.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

Late blight (*Phytophthora infestans*)

- Remove infected plant debris after harvest.
- Crop rotation with non-solanaceaous crops.
- Provide sufficient drainage.
- Maintain optimum spacing to allow free air circulation.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

Bacterial wilt (*Pseudomonas solanacearum*)

- Field sanitation and remove infected plants immediately after the appearance of the symptom.
- Crop rotation with non-solanaceous crops.
- Spray copper fungicide Bordeaux mixture @ 1% (10 g $CuSO_4$ + 10 g lime + 1 litre water) or COC @ 0.25 per cent.
- Raise soil pH with dolomite application @ 200 gm/m^2 and increase the calcium content in the soil.
- Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.
- Apply plant resistance inducer.
- Incorporate *Brassica* spp. at flowering stage as manure.
- Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 litre of water) to drench the soil 3 times *i.e.*, at 15, 30 and 45 days after transplanting.
- Flood the field one or two weeks before planting.
- Control root knot nematode to avoid plant injury.
- Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.
- Use resistant varieties *viz*., Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Arka Alok, Arka Abha, Swaraksha, NS-52, 53, 537, 247, 501, 4032, VT-1, 4.

Tomato mosaic virus

- Use disease-free seeds.
- Avoid smoking in the field.
- Wash hands with soap and water before and after handling infected plants.
- Avoid the soil in which the previous crop was infected.

Tomato leaf curl (*Tomato leaf curl virus*)

- Remove and destroy infected plants.
- Use yellow sticky traps to monitor and control white flies.
- Apply petroleum oil-based agro spray @ 7 ml/litre.
- Remove alternate or collateral hosts.
- Use resistant varieties *viz*., Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Kashi Amrit, Shaktiman, Ananya, Vaibhav, Uttam, NS-510, 524, 534.

Tomato spotted wilt virus

- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew (*Erysiphe polygoni*)

- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Capsicum

Anthracnose (*Colletotrichum capsici*)

- Use disease-free seeds.
- Collect and destroy infected plant debris.
- Apply Bordeaux mixture @ 1 per cent at 20 days interval commencing from one month after transplanting.

- Spray copper oxychloride @ 2.5 per cent thrice at 15 days interval starting from observing the die-back symptoms.
- Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 2 per cent.
- Use of plant extracts like sweet flag, tulsi and neem oil are reported to control the disease.

Cercospora leaf spot (*Cercospora capsici*)

- Remove and burn crop debris.
- Spray copper oxychloride @ 0.25 per cent.
- Adequate spacing should be given to avoid leaf wetness and improve air circulation.

Damping off (*Pythium* spp.)

- Destroy plant debris after harvest.
- Sowing seed on raised beds of 6-8" high (15 cm).
- Use low seed rate of 650 g/cent.
- Crop rotation with non-host crops like mustard.
- Apply well-decomposed FYM.
- Treat nursery soil with *Trichoderma viride* @ 2 per cent.
- Seed treatment with *Trichoderma viride* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed 24 hours before sowing.
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM.
- Water stagnation should be avoided
- Drench with copper oxychloride @ 2.5 g/lit or Bordeaux mixture @ 1 per cent.

Phytophthora blight (*Phytophthora capcisi*)

- Poorly-drained soil and excess watering should be avoided.
- Mulch the soil to avoid direct contact of fruits with soil.

- Overhead irrigation should be avoided.
- Remove and destroy the infected plant as soon as symptoms appears.
- Crop rotation with non-solanaceous crops like cereals, oilseeds and pulses.

Chilli mosaic (*Chilli mosaic virus*)

- Remove and destroy affected plants.
- Use virus-free seedlings.
- Growing barrier crops like maize (2-3 rows) around chillies to reduce the disease incidence.

Leaf curl (*Gemini virus*)

- Remove and destroy affected plants.
- Use neem oil or NSKE @ 0.3 per cent and @ 5 per cent, respectively to control aphids.

Cauliflower

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and remove infected plants.
- Planting cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).

- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

Wiry stem/Damping off (*Rhizoctonia solani*)

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)

- Use certified seeds.
- Hot water treatment of seeds at 50^{o}C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.

Vegetable cropping sequence for open condition

1. Okra - pea - spinach (leafy vegetables)

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Okra	Third week of March	Transplant in third week of April or direct sowing in April.	Pusa Sawani, Pusa Makhmali, Parbhani Kranti, Arka Anamika, Bhindi No. 10, Sikkim Local-1 *etc.*	15 - 20 kg	FYM @ 1.5-2.0 kg/m^2 mixed with biofertilizer *Azospirillum* @ 2 kg/ha and dolomite @ 200 g/m^2 at the time of bed preparation.	Planting / sowing should be done in rows either on ridges or on raised bed. Seed should be treated with *Trichoderma viride* @ 1 g/kg seed	45 cm row to row, 30 cm plant to plant	If no rain then manual irrigation at 3-5 days interval for establishment of seedlings or soil should be kept moist till direct sown seed germinates.	Crop should be weed free for full season. Manual weeding should be done at 10-15 days interval.	Regular picking of pods increases the yield. Pods are harvested at about 10 cm length. Delay in harvesting causes fibrous and matured fruits which get lower price in market.
Pea	-	First week of November	TSX-10, Pant Sabzi Matar-3 Pusa Pragati, VRP-5, VRP-6, Dentame *etc.*	100-125 kg	FYM @ 1.5-2.0 kg/m^2 at the time of bed preparation.	Sowing should be done in rows either on ridges, furrows or flat land.	30 cm x 30 cm; and for Dentame 45 cm row-row, 30 cm plant to plant.	Soil kept moist till germination and then irrigate at flowering and pod filling stage.	Three manual weeding at 10-15 days interval.	Multiple harvesting of mature green pods with pedicel and minimum disturbance to the plants.
Spinach	-	Third week February	All Green, Pusa Jyoti *etc.*	15 kg	Vermicompost @ 0.5-1.0 kg/m^2 at the time of bed preparation	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 7-10 days interval.	Three manual weeding at 10 days interval.	Leaf should be cut when attains marketable size or at 6-9" height plant should be uprooted.

2. Red cherry pepper (dalley) + fenugreek/coriander/spinach (as intercrops)

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Red cherry pepper (dalley)	First week of March	Third week of April	Red cherry pepper (dalley)	1.0 - 1.5kg	FYM @ 2-2.5 kg/m^2 mixed with neem cake @ 2 kg/m^2 and biofertilizer *Azospirillum* @ 2 kg/ha and dolomite @ 200 g/m^2 should be applied at the time of planting.	Planting should be done in rows either on ridges or on raised bed. Seedlings root dip with *Azospirillum* + PSB (20 %) for 15 minutes before planting.	100 cm x 100 cm	If no rain then manual irrigation at 3-5 days interval for establishment of seedlings. Later on crop should be rainfed.	Crop should be weed free for full season. Manual weeding should be done at 10-15 days interval. Mulching with *chilaune*, *titepati* or plastics is beneficial for weed and disease control.	First picking should be done at green stage to stimulate further flush of flowers and fruit set. Chilli for vegetable purposes is generally harvested at fully grown green stage whereas for dried chilli fruits at ripe stages are ideal.
Fenugreek	-	Third week of April	Local, Pusa Kasuri, Prabha, Sag Kalmi *etc.*	20-25 kg	Not required	Sowing should be done in two rows in between the rows of Red cherry pepper (dalley) plants	15 cm row to row, 3-5 cm plant to plant	If no rain then manual irrigation at 10 days interval.	Manual weeding as per requirement.	Harvesting should be done at 6-7" height and whole plant should be uprooted.
Coriander	-	First week of August	Pant Haritma, Super Midori, Rachna *etc.*	20-25 kg	Vermicompost @ 0.5-1.0 kg/m^2	Sowing should be done in two rows in between the rows of Red cherry pepper (dalley) plants	15 cm row to row, 3-5 cm plant to plant	Rainfed crop	Manual weeding as per requirement.	Harvesting should be done at 6-7" height and whole plant should be uprooted.
Spinach	-	First week of December	All Green, Pusa Jyoti *etc.*	10 kg	Not required	Sowing should be done in two rows in between the rows of Red cherry pepper (dalley) plants.	15 cm row to row, 3-5 cm plant to plant	If no rain then manual irrigation at 10 days interval.	Manual weeding as per requirement.	Leaf should be cut when attains marketable size or at 6-9'' height plant should be uprooted.

Crop protection

Insect pests management

- Shoot and fruit borer, Jassids, white fly, aphids and Blister beetle are some important pests of okra.
- Install pheromone traps @ 16-20 traps/ha for trapping of *Earias vittella* moths. Replace the lures at 20-25 days interval.
- Two to three sprays of petroleum-oil based agro spray @ 10 ml/litre or neem oil (1500 ppm) @ 3 ml/litre for management of leaf hopper, white fly, aphids *etc*. in okra and aphids in pea.
- Blister beetle can be managed by manual collection and destruction and spraying of neem-based formulation @ 3 ml/litre or *Beauveria bassiana* @ 5 g/litre at the time of flowering.
- Wood ash can also be used to repel the insect.
- White fly, aphids, tea mosquito bug and fruit borer cause economic damage in chilli.
- Use petroleum-oil based agro spray @ 10 ml/l or neem oil (1500 ppm) @ 3 ml/litre and second spray at 20 days interval to control whitefly, aphids, tea mosquito bug in Red cherry pepper (dalley).
- Regularly monitor, collect and destroy larvae of fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/litre and second spray at 20 days interval is effective to control of fruit borer. Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.
- No major insect pests problem reported in fenugreek, spinach and coriander.

Disease management

Okra

Yellow Vein Mosaic (*Yellow vein mosaic virus*)

- Grow tolerant varieties like Pusa A-4, Arka Abhay, Arka Anamika, Hisar Naveen.
- Grow tolerant varieties like Varsha Uphar, Hisar Unnat, HBH-142 (F1 hybrid), and Azad Bhindi.

- The early sown crop is less affected as compared to July sown.
- Remove and destroy infected plants.
- Use neem oil @ 3 per cent or NSKE @ 5 per cent or petroleum oil-based agro spray @ 7 ml per l of water to control the vector.

Powdery mildew (*Erysiphe polygoni*)

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. The first spray is done after the appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Application of finely ground sulphur @ 30 kg/ha is also found effective.

Pea

Wilt and Root rot (*Fusarium oxysporum* and *Rhizoctonia solani*)

- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.
- Use resistant varieties *viz.*, JP Batri Brown-3 and JP Batri Brown-4.
- Drench soil with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

Powdery mildew (*Erysiphe polygoni*)

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.

- Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.
- Varieties maturing in January usually escape the maximum intensity of the disease.
- Dusting sulphur @ 25 kg/ha is also recommended.
- Use resistant varieties *viz*., Pusa Pragati, Pusa Prabhat (DDR-23), Pusa Panna (DDR-27) Arka Ajit, Arka Karthik and Arka Sampoorna, Pant Sabji Matar-4, Pant Sabji Matar-5, Azad P-2, Azad P-4, Azad P-5.

Rust (*Uromyces fabae*)

- The affected plant trash should be burnt after harvest.
- Follow suitable crop-rotation with non-leguminous crops.
- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.
- Early sowing in the month of October.
- Use resistant varieties *viz*., Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.

Red cherry pepper (Dalley chillies)

Anthracnose (*Colletotrichum capsici*)

- Use disease-free seeds.
- Collect and destroy infected plant debris.
- Apply Bordeaux mixture @ 1 per cent at 20 days interval commencing from one month after transplanting.
- Spray copper oxychloride @ 2.5 per cent thrice at 15 days interval starting from observing the die-back symptoms.
- Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 2 per cent.
- Use of plant extracts like sweet flag, tulsi and neem oil are reported to control the disease.

Cercospora leaf spot (*Cercospora capsici*)

- Remove and burn crop debris.
- Spray copper oxychloride @ 0.25 per cent.
- Adequate spacing should be given to avoid leaf wetness and improve air circulation.

Damping off (*Pythium* spp.)

- Destroy plant debris after harvest.
- Sowing seed on raised beds of 6-8" high (15 cm).
- Use low seed rate of 650 g/cent.
- Crop rotation with non-host crops like mustard.
- Apply well-decomposed FYM.
- Treat nursery soil with *Trichoderma viride @* 2 per cent.
- Seed treatment with *Trichoderma viride* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed 24 hours before sowing.
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM.
- Water stagnation should be avoided
- Drench with copper oxychloride @ 2.5 g/lit or Bordeaux mixture @ 1 per cent.

Phytophthora blight (*Phytophthora capcisi*)

- Poorly-drained soil and excess watering should be avoided.
- Mulch the soil to avoid direct contact of fruits with soil.
- Overhead irrigation should be avoided.
- Remove and destroy the infected plant as soon as symptoms appears.
- Crop rotation with non-solanaceous crops like cereals, oilseeds and pulses.

Chilli mosaic (*Chilli mosaic virus*)

- Remove and destroy affected plants.
- Use virus-free seedlings.
- Growing barrier crops like maize (2-3 rows) around chillies to reduce the disease incidence.

Leaf curl (*Gemini virus*)

- Remove and destroy affected plants.
- Use neem oil or NSKE @ 0.3 per cent and @ 5 per cent, respectively to control aphids.

Fenugreek

Powdery mildew (*Erysiphe polygoni* and *Leveillula taurica*)

- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extracts @ 5 per cent.

Spinach: Major diseases have not been found in spinach under Sikkim conditions.

3. Okra - garlic

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Okra	Third week of March	Transplant in third week of April or direct sowing in April.	Pusa Sawani, Pusa Makhmali, Parbhani Kranti, Arka Anamika, Bhindi No. 10, Sikkim Local-1 *etc.*	15 - 20 kg	FYM @ 1.5 - 2.0 kg/m^2 mixed with biofertilizer *Azospirillum* @ 2 kg/ha and dolomite @ 200 g/m^2 at the time of bed preparation.	Planting/ sowing should be done in rows either on ridges or on raised bed. Seed should be treated with *Trichoderma viride* @ 1 g/kg seed	45 cm row to row, 30 cm plant to plant	If no rain then manual irrigation at 3-5 days interval for establishment of seedlings or soil should be kept moist till seed germinates for direct sowing.	Crop should be weed free for full season. Manual weeding should be done at 10-15 days interval.	Regular picking of pods increases the yield. Pods are harvested at about 10 cm in size. Delay in harvesting causes fibrous and matured fruits which get lower price in market.
Garlic	-	First week of November	Agrifound White, Agrifound Parvati, Yamuna Safed, VL Garlic-1, VL Lahsun-2, Sikkim Local garlic	300 - 500 kg	FYM @ 1.5 - 2.0 kg/m^2 at the time of planting and vermicompost @ 0.5-1.0 kg/m^2 60 days after planting.	Planting / sowing should be done in rows either on ridges or on raised beds.	15 cm row to row, 10 cm plant to plant	Light irrigation at 7-10 days interval. Over watering should be avoided.	Manual weeding should be done at 10-15 days interval.	Harvesting should be done after 4-5 months of planting when the top leaves becomes yellowish and fall down after drying. Bulbs collected with leaves and small bundles should be made.

4. Ginger - pea

Crop	Nursery sowing	Sowing/ transplanting time	Varieties/ cultivars	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Ginger	-	First week of March	Bhaise, Gorubathane, Majhauley *etc.*	2.0 -2.5 tonnes	FYM @ 4-5 kg/m^2 mixed with neem cake @ 2 kg/m^2 biofertilizer *Azospirillum* + PSB @ 5-6 kg/ha and dolomite @ 200 g/m^2 at the time of planting should be applied in rows.	Healthy medium or small size (40-50 g) rhizomes with two good buds treated with hot water (50°C) and *Trichoderma viride* @ 2 g/kg rhizome for 30 minutes should be used for planting in rows on raised bed.	30-45 cm row to row and 15-20 cm plant to plant.	Generally irrigation is not required, however, proper drainage should be maintained and avoid water logging conditions.	2-3 manual weeding before manuring and first mulching with *chilaune* or *titepati* at 40-45 days and second at 90 days after planting. Maize should not be grown as an intercrop.	Healthy plants should be selected for seed purpose rhizome and should be harvested first before harvesting rest of the crop.
Pea	-	Third/fourth week of November	TSX-10, Pant Sabzi Matar-3, Pusa Pragati, VRP-5, VRP-6, Dentame *etc.*	100 - 125 kg	FYM @ 1.5 -2.0 kg/m^2 at the time of bed preparation.	Sowing should be done in rows either on ridges, furrows or flat land.	Dentame 45 cm row to row, 30 cm plant to plant and for others 30 cm x 30 cm	Soil kept moist till germination and then irrigate at flowering and pod filling stage.	Three manual weeding at 10-15 days interval.	Multiple harvesting of mature green pods with pedicel and minimum disturbance to the plants.

Crop protection

Insect pests management

- Shoot and fruit borer, Jassids, white fly, aphids and Blister beetle are some important pests of okra.
- Install pheromone traps @ 16-20 traps/ha for trapping of *Earias vittella* moths. Replace the lures at 20-25 days interval.
- Give two to three sprays of petroleum-oil based agro spray @ 10 ml/l or neem oil (1500 ppm) @ 3 ml/l for management of leaf hopper, white fly, aphids *etc*. in okra and aphids in pea.
- Blister beetle can be managed by manual collection and destruction and spraying of neem-based formulation @ 3 ml/l or *Beauveria bassiana* @ 5 g/l at the time of flowering.
- Wood ash can also be used to repel the insect.
- No insect pests cause economic damage in garlic.
- In ginger, shoot borer and white grub are major problems.
- Spray neem oil (1500 ppm) @ 3 ml/l at 20 days interval for management of shoot borer and apply *Beauveria bassiana* or *Metarhizium anisopliae* @ 5 kg/ha during field preparation for management of white grub.

Disease management

Okra

Yellow Vein Mosaic (*Yellow vein mosaic virus*)

- Grow tolerant varieties like Pusa A-4, Arka Abhay, Arka Anamika, Hisar Naveen.
- Grow tolerant varieties like Varsha Uphar, Hisar Unnat, HBH-142 (F1 hybrid), and Azad Bhindi.
- The early sown crop is less affected as compared to July sown.
- Remove and destroy infected plants.

- Use neem oil @ 3 per cent or NSKE @ 5 per cent or petroleum oil-based agro spray @ 7 ml per l of water to control the vector.

Powdery mildew (*Erysiphe polygoni*)

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. The first spray is done after the appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Application of finely ground sulphur @ 30 kg/ha is also found effective.

Garlic

Damping off (*Pythium* spp., *Phytophthora* spp., *Rhizoctonia solani*, *Fusarium* spp.)

- Healthy seed should be selected for sowing.
- The seed should be treated with *Trichoderma viride* @ 4 g/kg of seed before sowing.
- Continuous raising of nursery in the same plot should be avoided.
- Application of bio-control agent *Trichoderma viride* in soil @ 1.2 kg/ha is also found effective to control damping-off to considerable extent.

Purple blotch (*Alternaria porri*)

- Lowering the density of transplanted crops.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture@ 0.1 per cent.
- Tolerant varieties *viz*., Yamuna Safed (G-1), Yamuna Safed-5 (G-189), Pant Lohit.

Stemphylium blight (*Stemphylium vesicarium*)

- Lowering the density of transplanted crops.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent.

- Tolerant varieties *viz*., Yamuna Safed (G-1), Yamuna Safed-5 (G-189).

White rot (*Sclerotium cepivorum*)

- Seedling dip in *Trichoderma viride*.
- Soil application of *Trichoderma viride* @ 2.5 kg in 50 kg well rotten FYM for 1 ha land.

Powdery mildew (*Leveillula taurica*)

- Spray wettable sulphur solution @ 0.2 per cent.

Pea

Wilt and Root rot (*Fusarium oxysporum* and *Rhizoctonia solani*)

- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.
- Use resistant varieties *viz*., JP Batri Brown-3 and JP Batri Brown-4.
- Soil drenching with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

Powdery mildew (*Erysiphe polygoni*)

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.
- Varieties maturing in January usually escape the maximum intensity of the disease.
- Dusting sulphur @ 25 kg/ha is also recommended.

- Use resistant varieties *viz.*, Pusa Pragati, Pusa Prabhat (DDR-23), Pusa Panna (DDR-27) Arka Ajit, Arka Karthik and Arka Sampoorna, Pant Sabji Matar-4, Pant Sabji Matar-5, Azad P-2, Azad P-4, Azad P-5.

Rust (*Uromyces fabae*)

- The affected plant trash should be burnt after harvest.
- Follow suitable crop-rotation with non-leguminous crops.
- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.
- Early sowing in the month of October.
- Use resistant varieties *viz.*, Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.

Ginger

Soft rot (*Pythium aphanidermatum*, *P. myriotylum* and *P. vexans*)

- Use disease-free, healthy rhizome for planting.
- Hot water treatment of rhizome at 50°C for 30 min. followed by treatment of the rhizome with *Trichoderma viride* (5 g/lit. water).
- Provide good drainage.
- Apply FYM and other organic manure to increase the population of beneficial microorganisms.
- Bio-fumigation with residues of cruciferous crops like mustard, toria, and rapeseed.
- Apply neem cake @ 2.5 quintals along with *Trichoderma viride* @ 2.5 kg per ha, respectively at the time of planting.
- Immediate removal of the infected plants and drenching with COC @ 0.3 per cent.
- Allow at least three years between the ginger crops planted on the same land.
- Drench with Bordeaux mixture @1 per cent or COC @ 0.3 per cent for effective control of the disease.

Bacterial wilt (*Ralstonia solanacearum*)

- Select disease-free or healthy seed rhizomes for sowing.
- Apply FYM and other organic manure to increase the population of beneficial microorganisms.
- Flood the field 2 or 3 weeks before sowing of ginger rhizome.
- Rotation of ginger crop with non-host crops like rice, wheat, maize or green manure crops.
- Solarization of seed rhizomes inside polythene for 2 hours.
- Biofumigation by growing mustard crop and incorporating the crop residues in to the field at the flowering stage can also suppress the pathogen.
- Control insects and nematodes by suitable organic pesticides because they serve as carriers of the pathogen and spread to healthy plants while feeding.
- Soil amendment with dolomite to increase the pH of the soil.
- Apply bleaching powder @ 25 kg per ha.
- Provide good drainage since water stagnation predisposes the plant to infection.
- Once the disease is noticed in the field all beds should be drenched with Bordeaux mixture @ 1 per cent.

Dry rot/yellows/Fusarium wilt (*Fusarium* spp.)

- Select disease free and healthy rhizome for planting.
- Crop rotation with non-host crops.
- Seed treatment (5 g/1 litre of water) and soil application of *Trichoderma viride* or *T. harzianum* @ 2.5 kg mixed with 50 kg of well rotten FYM for 1 ha.

5. Okra - potato - coriander (leafy vegetables)

Crop	Nursery sowing	Sowing/ transplanting time	Varieties	Seed rate/ ha	Nutrient management	Method of planting	Spacing (cm)	Water management	Intercultural operation	Harvesting
Okra	Third week of March	Transplant in third week of April or direct sowing in April.	Pusa Sawani, Pusa Makhmali, Parbhani Kranti, Arka Anamika, Bhindi No. 10, Sikkim Local-1 *etc*.	15 - 20 kg	FYM @ 1.5 - 2.0 kg/m^2 mixed with biofertilizer *Azospirillum* @ 2 kg/ha and dolomite @ 200 g/m^2 at the time of bed preparation.	Planting / sowing should be done in rows either on ridges or on raised bed. Seed should be treated with *Trichoderma viride* @ 1 g/kg seed.	45 cm row to row, 30 cm plant to plant.	If no rain then manual irrigation at 3-5 days interval for establishment of seedlings or soil should be kept moist till direct seed sown germinates.	Crop should be weed free for full season. Manual weeding should be done at 10-15 days interval.	Regular picking of pods increases the yield. Pods are harvested at about 10 cm in size. Delay in harvesting causes fibrous and matured fruits which gets lower price in market.
Potato	-	First week of November	Kufri Giriraj, Kufri Jyoti, Kufri Sheetman, Kufri Sinduri, Sikkim Local *etc*.	1.5-2.0 tonnes	FYM @ 2.0 - 2.5 kg/m^2 mixed with neem cake @ 200 g/m^2 at the time of bed preparation.	Healthy medium or small size sprouted tubers should be used for planting in rows either on ridges or on raised beds.	60 cm row to row, 30 cm tuber to tuber	Soil should be kept moist with frequent irrigation in furrows up to 2/3rd height of ridges. Heavy irrigation should be avoided.	Three manual weeding at 10-15 days interval. Deep cultivation is avoided. Earthing up should be done when plants are 15-20 cm tall.	Crop should be harvested 15 days after cutting the haulms when tuber skin is hard enough to withstand handling during harvest and transport from field to store.
Coriander	-	Second week of March	Pant Haritma, Super Midori, Khushboo, Rachna *etc*.	25 - 30 kg	FYM @ 2.0 - 2.5 kg/m^2	Sowing should be in rows.	15-20 cm row to row, 3-5 cm plant to plant	Manual irrigation at 10 days interval.	Two manual weeding at 7 days interval.	Harvesting should be done at 6-7'' height and whole plant should be uprooted.

Crop protection

Insect pests management

- Shoot and fruit borer, Jassids, white fly, aphids and Blister beetle are some important pests of okra.
- Install pheromone traps @ 16-20 traps/ha for trapping of *Earias vittella* moths. Replace the lures at 20-25 days interval.
- Give two to three sprays of petroleum-oil based agro spray @ 10 ml/l or neem oil (1500 ppm) @ 3 ml/l for management of leaf hopper, white fly, aphids *etc*. in okra and aphids in pea.
- Blister beetle can be managed by manual collection and destruction and spraying of neem-based formulation @ 3 ml/l or *Beauveria bassiana* @ 5 g/l at the time of flowering.
- Wood ash can also be used to repel the insect.
- Cutworms, Red ant and aphids cause economic damage in potato.
- Crop should be rotated with suitable non-host crop *viz*., rice and apply well-decomposed FYM for cut worm.
- Light traps should be laid in the fields to capture adults.
- Drenching of the base of the crop with neem oil (1500 ppm) @ 5 ml/l for cut worm and red ant.
- Two sprays of petroleum-oil based agro spray @ 10 ml/l or neem oil 0.15 EC (1500 ppm) @ 3 ml/l at 20 days interval is found effective against aphids in potato and pea.

Disease management

Okra

Yellow Vein Mosaic (*Yellow vein mosaic virus*)

- Grow tolerant varieties like Pusa A-4, Arka Abhay, Arka Anamika, Hisar Naveen.

- Grow tolerant varieties like Varsha Uphar, Hisar Unnat, HBH-142 (F1 hybrid), and Azad Bhindi.
- The early sown crop is less affected as compared to July sown.
- Remove and destroy infected plants.
- Use neem oil @ 3 per cent or NSKE @ 5 per cent or petroleum oil-based agro spray @ 7 ml per l of water to control the vector.

Powdery mildew (*Erysiphe polygoni*)

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. The first spray is done after the appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Application of finely ground sulphur @ 30 kg/ha is also found effective.

Potato

Late blight (*Phytophthora infestans*)

- It can be managed by adopting preventive measures *viz*., sprays of Blitox @ 5.0 g /l or Phytolan @ 2.5 g/l at 15 days interval.
- Use potato tubers for seed from disease-free areas to ensure that the pathogen is not carried through seed tuber.
- Remove and destroy infected plant material in the field.
- Growing resistant varieties like Kufri Navtal, Kufri Chipsona-1, Kufri Kanchan, Kufri Pushkar, Kufri Himsona, Kufri Sadabahar, Kufri Frysona, Kufri Chipsona-4, K Meghnad, Kufri Jyoti, Kufri Badshah, Kufri Jeevan, and Kufri Sherpa *etc*.

Early blight (*Alternaria solani*)

- Crop rotation should be followed for 2-3 years with non-solanaceous crops to avoid the disease incidence since the pathogen is soil-borne.
- Diseased plants should be uprooted and burnt just after detection in the field.
- Dead haulms should also be raked and burnt after harvest.
- Moderately resistant varieties are Kufri Naveen, K. Sindhuri and K. Jeevan. Hybrid 66-528/8 (*Solanum tuberosum* x *S. andigena*) is a source of high resistance to early blight.
- Spray copper oxychloride @ 0.25 per cent and Bordeaux mixture @ 1.0 per cent at 15 days interval control the disease.

Brown rot (*Ralstonia solanacearum*)

- Use disease-free seeds.
- Field sanitation.
- In case cut potato tubers are being used, they should be kept at 12°C for four days so that the cut surface hardens.
- Sow in disease-free field.
- Crop rotation with non-solanaceaous crop.
- Regular cleaning and disinfection all machinery, equipments and containers.
- Soil application of bleaching powder @ 12 kg per ha at the time of planting.

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.

Organic fruit production techniques

Sikkim is endowed with varied agro-climatic conditions suitable for the cultivation of large number of sub-tropical and temperate fruits. Horticultural crops occupy substantial portion of area and contribute more than 25-30% of the gross value of agricultural output of the country. Fruits are important sources of minerals and vitamins and provide part of the calorie requirement in the daily diet of the people. They also provide most of the food roughage, which contributes to the prevention of disorders of the digestive system. The nutritional status of diet is on a declining trend due to low intake of fruits. The increased production and intake of fruits by the people will help compensate for debilitating nutritional deficiencies. Fruit crop diversification is an important step for sustainable economic growth. As the economy grows, there is a gradual movement from subsistence food-crop production to a diversified market-oriented production system. Therefore, integrated development of organic horticulture is essential to improve the overall growth of the region. Emphasis should be laid on economically desirable crop intensification and increasing the production of fruits. The new concept of high density planting is highly suitable to Sikkim where land is a limitation and even small and marginal farmers can allocate certain portion of their land for cultivation of fruit crops especially mandarin, guava, papaya, pomegranate, pear, walnut *etc.* In Sikkim, many fruit crops can be grown at various altitudes, the altitudinal suitability for subtropical and temperate fruits in Sikkim are given in Table 1.

Table 1. Fruits suitable for subtropical to temperate regions of Sikkim

Altitude	Suitable fruit crops
Lower hills (300-900 m)(with chilling temperatures up to 500 hrs)	Sikkim mandarin, guava, papaya, banana, pomegranate, *etc.*
Mid hills (900-1800 m)(fruits with moderate chilling requirements*i.e.*, 500 - 1000 hrs)	Sikkim mandarin up to 1600 m, Pear (Asian and Japanese pears), litchi, kiwifruit and walnut
High hills (1800-2500 m)(fruits with sufficient chilling requirements *i.e.*, > 1000 hrs)	Pears (European type), kiwifruit

The brief crop-wise details of fruit crops' cultivation is given in the following pages.

Sikkim mandarin (*Citrus reticulata* Blanco.)

1. Land preparation

- The land for planting mandarin should be well ploughed and all weeds should be removed.

- The rows should be oriented in north-south direction to maximize the use of sunlight.

- Pits of 3' x 3' x 3' (length, width and depth, respectively) are dug and refilled with the top 1½' soil, mixed with 20-25 kg of well-decomposed farmyard manure or compost at least 1-2 months before actual planting.

2. Time of planting

- In Sikkim, planting is done after the first monsoon rains during June-July.

3. Method of planting

- Sikkim mandarin is recommended to be planted at a distance of 5 m x 5 m on terraces in contour system of plantation. Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties: Sikkim mandarin

5. Organic nutrient management

- Bearing mandarin plants should be manured twice in a year *i.e.*, June-July and after harvesting in December-January.

- During 1-7 years age, FYM @ 15-25 kg/tree and/or vermicompost @ 4.5-9 kg/tree may be applied.

- After seven years, 25-50 kg FYM/tree and/or 15-30 kg vermicompost/tree may be applied annually in two equal splits either sole or in combination for sustained optimum yield.

- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.

- Micronutrients are essential for proper growth and fruiting in mandarin and these can be applied through foliar sprays of water soluble organic sources @ 0.2 per cent.

- Soil amendment such as dolomite @ 100-200 g/plant may be applied every second year based on soil test values to maintain the soil pH.

- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

6. Intercropping

- Commercial fruit bearing in Sikkim mandarin orchard generally starts after 5 to 6 years; until then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, beans, French bean, gram, and leafy vegetables, root vegetables *etc*., or any other traditional crop in rotation.
- Exhaustive crops *viz*., maize, ginger *etc.* which drain the essential nutrients and moisture quickly from the field should be avoided as intercrops.
- Intercrops having high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. Water management

- Mandarin requires protective irrigation in the first year during winter and summer. Irrigation improves the plant growth, flowering and fruiting in mandarin.
- Irrigation of orchards at every 10 to 15 days interval from November to February promotes heavy flush in March-April followed by good flowering and fruit-set.
- The young and bearing plants should be irrigated by basin or ring system. Drip system of irrigation can also be used for the conservation of water especially during winter.

8. Weed management

- Frequent hoeing, hand-weeding and light tillage are essential in reducing the weed growth and maintain porosity and tilth especially during summer season.
- Hand-weeding should be done carefully to avoid injury to the roots.
- Ploughing, spading of basins, weed control, *etc.* are important inter-cultural operations for soil aeration and tree health.

9. Training and pruning

- Trees are trained to single stem with 4-6 well-spaced branches for making the basic framework. Further, the lowest branches should not be below 50 cm.
- The best time of pruning of bearing trees is when these trees are dormant *i.e.*, should be performed after harvest during late winter or early spring.

- The centre of the plant should remain open. Branches should be well-distributed on all sides. Cross-twigs and water suckers are to be removed early. All diseased, injured and drooping branches and deadwood are to be removed periodically.

10. Mulching

- Mulching is essential to avoid weed problem in the field during rainy season and also for moisture conservation during winter season.
- Mostly, leaf mulch is recommended for mandarin plantations. The best mulching material in Sikkim is *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*), which minimize some disease problems also.

11. Crop protection

Insect pests management

- Clean trunk and apply Bordeaux paste in April from the base of the trunk up to 1 m height.
- Frequent monitoring of the orchard.
- Two sprays of petroleum-oil based agro spray @ 10 ml/l during April-May for control of aphids and leaf miner and one spray of *Bacillus thuringiensis* @ 2 g/l when infestation of lemon butterfly is observed is recommended.
- Cleaning of infested plants and insertion of iron wire to kill the larvae and insertion of cotton soaked in petrol or kerosene in to the holes followed by plastering with soil and cow dung mixture is recommended for management of trunk borer and bark eating caterpillar.
- September onwards install methyl eugenol-based para pheromone traps to manage fruit fly.
- The dropped infested fruits should be collected on community basis and must be either buried under the soil or destroyed by keeping in hot water to reduce the infestation of fruit fly.
- During August-September spray of petroleum-based oil agro spray @ 10 ml/l should also be done in case of occurrence of aphids and leaf miner and one spray of *Bacillus thuringiensis* @ 2 g/l when the infestation of lemon butterfly is observed.
- Yellow colour trap can be installed in the field throughout the year to trap the population of aphids, leaf miner and psylla.

Disease management

Gummosis or Foot rot (*Phytophthora* spp.)

- Follow ring system of irrigation by heaping the earth around the tree trunk.
- Provide an inner ring of about 45 cm around the tree trunk to prevent water logging. (double ring method of irrigation).
- Select disease-free saplings.
- Bud union should be kept 15-20 cm above the ground level.
- Good drainage should be provided.
- Injury to the root should be avoided.
- Apply recommended dose of FYM and other organic manures.
- Treat soil with *Trichoderma harzianum* @ 2 per cent.
- Diseased and dead bark of the tree trunk should be scraped with sharp knife and Bordeaux paste or $ZnSO_4$: $CuSO_4$: lime (5:1:4) should be applied on tree trunk up to 45-60 cm.
- Drenching with Bordeaux mixture @ 1 per cent or COC @ 0. 25 per cent.
- Drench soil with 0.5 per cent *Trichoderma viride*. Commercial formulation is also effective.
- Sprout removal and pruning are best done only in dry weather.

Powdery mildew (*Acrosporium tingitanium*)

- Apply wettable sulphur @ 0.2 per cent.
- Remove water shoots.
- Remove affected plant parts.

Scab (*Elsinoe fawcetti*)

- Remove and destroy infected parts.

- Apply Bordeaux mixture @ 1 per cent or copper oxychloride @ 0.3 per cent at 15 days interval.

Greasy spot or Black melanose (*Mycospherella citri*)

- Spray copper oxychloride @ 0.3 per cent during new flush formation and the spray should be carried out under the leaf surface.
- Remove severely infected twigs.

Twig blight or Die back (*Diplodia natalensis* and *Colletotrichum gloeosporioides*)

- Spray copper oxychloride @ 0.25 per cent during new flush formation and the spray should be carried out under the leaf surface.
- Remove severely infected twigs.
- Twig blight or wither tip or dry-up twigs can be effectively managed by pruning during January/February followed by two sprays with @ 0.25 per cent at 30 days interval.

Citrus greening (*Candidatus liberibacter* var. *asiaticus*)

- Remove, uproot infected plants and burn.
- Control insect vector (psyllid) using petroleum oil-based agro spray @ 0.7 per cent or NSKE @ 5 per cent or neem oil @ 0.3 per cent.

Quick decline/Citrus Tristeza (Citrus tristeza virus)

- Select seedlings from disease-free field.
- Infected trees should be removed.
- Use tolerant rootstocks for grafting like Rangpur lime, Jattikhatti, Cleopatra mandarin and Citranges.
- CTV is not seed-borne, so nucellar seedlings are free from the disease.
- Control insect vectors using petroleum oil-based agro spray @ 0.7 per cent or NSKE @ 5 per cent or neem oil @ 0.3 per cent.
- Cross protection with mild strains.

12. Harvesting

- All citrus ripen gradually over weeks or months and are slow to abscise from the tree. External color changes during ripening but is a function of climate more than ripeness; and a poor indicator of maturity.
- The main harvesting season of Sikkim mandarin is October to January. Plucking the fruits directly from the tree should be avoided, as it usually removes portion of the skin which later causes problem in storage. Removing the fruits with a portion of peduncle from the trees is an ideal method of harvesting.

Guava (*Psidium guajava* L.)

1. Land preparation

- Soil should be well ploughed and all weeds should be removed.
- Pits of 3' x 3' x 3' (length, width and depth, respectively) are dug and refilled with the top 1½' soil mixed with 20-25 kg of well-decomposed farmyard manure or compost at least 1-2 months before actual planting.

2. Time of planting

- In Sikkim, planting is done during the monsoon rain in June-July.

3. Method of planting

- High density guava is planted at distance of 2 m x 1.5 m on terraces in contour system of plantation. However, generally planting of guava is done at distance 4 m x 4 m. High-density planting gives higher yield/unit area in early years of fruiting.
- The rows should be oriented in north-south direction to maximize the use of sunlight.
- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties

- **Allahabad Safeda, Lucknow-49 (Sardar), Chittidar, Apple Colour**, Arka Mridula, Allahabad Surkha, Hissar Safeda, Pear Shaped, CISH G-1, CISH G-2 *etc*.
- **Lines:** RCGH-1, RCGH-4, RCGH-7, RCGH-11

5. Organic nutrient management

- Guava plants should be manured twice in a year *i.e.*, June-July and December-January.
- FYM @ 15-25 kg/tree and/or vermicompost @ 4.5-9 kg/tree may be applied annually in two equal splits either sole or in combination for sustained optimum yield.
- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.
- Micronutrients are essential for proper growth and fruiting in guava and these can be applied through foliar sprays of water soluble organic sources @ 0.2 per cent.
- Application of soil amendment such as dolomite every second year @ 100-200 g/plant is essential to maintain the soil pH.
- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

6. Intercropping

- Commercial fruit bearing generally starts after 3 to 5 years until then the interspaces between the young trees should be intercropped with leguminous crops like pea, beans, French bean, gram, and leafy vegetables, root vegetables *etc.*
- Intercrops having high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. Water management

- Guava is generally grown as rainfed crop and irrigation is rarely practiced. Just after planting, watering is given in the absence of rains.
- Irrigation improves the plant growth, flowering and fruiting in guava.
- Irrigation during winter months has been found to reduce fruit drop and improve fruit size of winter crop.
- Irrigation is given to make the soil root zone moist; thus, heavy irrigation is unnecessary. The fruit quality of guava is adversely affected by high moisture content during harvest. Therefore, drip system of irrigation shall be best for harvesting quality fruits and conservation of water during winter months.

8. Weed management

- Manual weeding with the help of *khurpi* or hand hoe is the best pre-monsoon method to control the weed population.
- Hand-weeding should be done carefully to avoid injury to the roots.
- Ploughing, spading of basins, *etc.* are important inter-cultural operations for soil aeration and tree health.

9. Training and pruning

- Training of guava plants in young stage to build strong framework and to avoid weak crotches is necessary; whereas, fruiting trees should be pruned to check over-crowding in the orchard.
- The plants should be trained as low headed trees to facilitate multiple hand pickings.
- The open centre or delayed open centre system may be adopted. The scaffold branches in young plants are to be tipped back to encourage secondary branching.
- The root suckers, water sprouts and criss-cross branches are to be removed.
- Pruning is also undertaken during harvest as the fruit is plucked along with the shoot on which it is borne. Pruning is usually recommended after harvest or in spring.

10. Mulching

- Mulching is essential to avoid weed problem in the field during rainy season and for moisture conservation during winter season.
- Mostly, leaf mulch is recommended for guava plantations. The best mulching material in Sikkim is *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*), which minimize some disease problems also.
- Weed growth can also be checked by mulching with black plastic mulch.

11. Crop protection

Insect pests management

- Fruit fly, bark eating caterpillar, tea mosquito bug and spiraling whitefly are some important pests of guava.

- Collect and destroy fallen and infested fruits, summer ploughing to expose pupae, use methyl eugenol lure traps @ 25/ha to monitor and kill adults of fruit flies; and harvesting of the fruits should be done early for management of fruit fly.
- In order to manage bark eating caterpillar, hook out the grub from the bore hole. Clean infested portion followed by insertion of cotton soaked in kerosene oil in to the holes and closing of the holes by plastering with mud.
- Swab coal tar + kerosene @ 1:2 of water on the basal portion of the trunk up to 3 feet height.
- Collect and destroy the damaged plant parts for management of tea mosquito bug. Apply neem oil (1500 ppm) @ 3 ml/l at 15 days interval at the time of flowering and fruiting.
- Spiraling whiteflies can be managed through field sanitation, installation of yellow sticky traps and application of petroleum oil-based agro spray @ 10 ml/l at 15 days interval.

Disease management

Wilt (*Fusarium oxysporum* f. sp. *psidii*)

- Planting should be done in well-drained soil.
- Remove and destroy infected tree along with root.
- Soil treatment with lime (1.82 kg lime/tree) to prevent further spread of the disease.
- Apply 6 kg neem cake + 200 g dolomite per plant.
- Intercrop with turmeric or marigold to check the wilting of guava.
- Apply green manure or any other organic sources of nitrogen.

12. Harvesting

- Seedling guava tree requires 4-5 years to bear, while grafted, budded or layered plants start bearing at age of 2-3 years.
- Fruits are recommended for harvest between 106 to 121 days after fruit set to ensure higher amount of total sugars and appreciable amount of minerals.
- Guava fruit develop best flavor and aroma only when they ripen on tree. The fruits are harvested selectively by hand along with the stalk and leaves.

- Ripening of guava starts on the tree and continues even after harvest. It is accelerated in rainy season due to high temperature and slows down in winter season due to low temperature.

Papaya (*Carica papaya* L.)

1. Land preparation and sowing

- Papaya does not withstand waterlogging, hence, upland should be selected for its cultivation. Plants are also sensitive to strong wind, so suitable windbreaks are essential to protect them.
- Soil should be well ploughed and all weeds should be removed.
- Pits of 2' x 2' x 2' (length, width and depth, respectively) are dug and refilled with the top 1' soil mixed with 20-25 kg of well-decomposed farmyard manure or compost at least 15-20 days before actual planting.
- About 250-300 gm seeds are sufficient for one hectare. Seedlings can be raised in nursery beds of 3 m length, 1 m width and 10 cm height as well as in pots or polythene bags. In Sikkim conditions, time of sowing is February to April.

2. Time of planting

- Papaya is planted during monsoon (June-July) and autumn (October-November) in Sikkim conditions.
- Monsoon planting is done in frost prone areas and autumn planting is preferred in high rainfall areas.

3. Method of planting

- Planting distance is determined by the integration of light interception, cultivar and economic consideration. Spacing of 1.8 m x 1.8 m is normally followed for most of the cultivars. Spacing of 1.4 m x 1.4 m or 1.4 x 1.6 m is best suited for Pusa Delicious. Closer spacing of 1.3 m x 1.3 m is optimum for Coorg Honey Dew, and 1.2 m x 1.2 m for Pusa Nanha.
- Planting of papaya saplings should be done in the evening. The seedlings from nursery-beds are lifted with a ball of earth and planted in the field. Plants raised in polythene bags are planted after removal of polythene. It is important to keep some extra saplings for gap-filling.

- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties

- Pusa Dwarf, Pusa Nanha, Coorg Honey Dew, Solo Sunrise, Sinta, Taiwan, Pusa Majesty, Washington, Pusa Delicious, Pusa Giant *etc.*

5. Organic nutrient management

- Papaya is heavy feeder and requires heavy doses of manures. Basal dose of 20 kg FYM/pit should be applied and properly incorporated with the soil. FYM @ 15-25 kg/tree and/or vermicompost @ 4.5-9 kg/tree may be applied annually in two equal splits as either sole or in combination for sustained optimum yield.
- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.
- Application of soil amendment such as dolomite @ 100-200 g/plant every second year is essential to maintain the soil pH.
- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

6. Intercropping

- Any seasonal vegetable crop can be grown as intercrop in the interspaces available between rows. Suggested vegetables are cabbage, cauliflower, onion, radish *etc.* Planting of intercrops should be done just after establishment of papaya sapling.
- It is advised not to grow chillies, tomato, brinjal and Lady's finger as intercrops to avoid virus diseases since they serve as hosts.
- No intercropping should be undertaken when flowering and fruiting starts. Suitable crop rotation should be followed to maintain soil fertility and avoid replanting problem. Intercropping leguminous crops after non-leguminous ones, shallow-rooted crops after deep-rooted once are beneficial.

7. Water management

- Watering should be done soon after planting the sapling. Optimum soil moisture is essential for growth, yield and quality of fruits.
- Under low moisture conditions, floral sex shifts towards female sterility, resulting in poor yield. At the same time, over-irrigation may cause root rot diseases. Hence, efficient water management is essential.

- Generally, basin irrigation is used but care is to be taken to avoid water stagnation around the plant. In low rainfall areas where the water is scarce, sprinkler or drip irrigation system may be adopted to maximize water use efficiency.
- Papaya plant is highly susceptible to waterlogging. Even 24 hours water-logging may kill well established plant. Therefore, upland should be selected for papaya cultivation.

8. Weed management

- Weeds grow luxuriantly in papaya field and uptake most of the applied nutrients. Manual weeding with the help of *khurpi* or hand hoe is the best pre-monsoon way to control the weed population.
- Deep hoeing is recommended during first year to check weed growth. Hoeing should not be done in rainy season or after fruiting as the plants are shallow rooted. Over growth of weeds also causes waterlogging conditions and makes the plants vulnerable to root rot in rainy season. Therefore, the papaya field should be kept free from weed.

9. Mulching

- Mulching is essential to avoid weed problem in the field during rainy season and for moisture conservation during winter season.
- Mostly leaf mulch is recommended for mulching of papaya plantations. The best mulching material in Sikkim is *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*) which minimize some disease problems also.
- Weed growth can also be checked by mulching with black plastic mulch.

10. Crop protection

Insect pests management

- Red spider mite, fruit files, aphids and white flies are some important pests of papaya.
- Spray wettable sulphur @ 0.25% and repeat at intervals of 12-15 days for management of mites.
- Collect all fallen infested fruits and destroy for management of fruit fly. Install methyl eugenol based para-pheromone traps for monitoring and trapping of adult fruit flies.
- Apply petroleum oil-based agro spray @ 10 ml/l at 15 days interval for aphids and white flies.

Disease management

Powdery mildew (*Odium indicum, Odium caricae*)

- Spray wettable sulphur @ 0.25 per cent.
- Remove and destroy severely infected foliage.

Foot rot of papaya (*Pythium aphanidermatum*)

- *Trichoderma viride* @ 15 g/plant mixed in well-decomposed FYM should be applied around the root zone of the plants at the time of planting.
- The crop should be irrigated by adopting the ring method of irrigation so that the water does not come in direct contact with the stem.
- The soil should be drenched with 2-3 litres of @ 0.25 per cent or Bordeaux mixture. The application should be carried out regularly at 15 days interval from the time of planting.
- During fruit formation, the plant should be sprayed with the same solution at the same time interval. The rotted portion of the plant should be scraped and copper oxychloride or Bordeaux paste should be applied.
- The base of the plant should be drenched with three litres of copper oxychloride @ 0.25 per cent.
- The plant should be drenched during fruit formation with copper oxychloride @ 0.25 per cent twice at 15 days interval.

Papaya mosaic

- Removal and destruction of affected plant reduces the spread of the disease.
- Use tolerant variety, Pusa Majesty.
- Apply neem oil @ 0.3 per cent or @ NSKE 5 per cent or petroleum oil-based agro spray @ 0.7 per cent.

Leaf curl of papaya

- Remove and destroy the affected plants.
- Use tolerant variety, Pusa Majesty.

- Apply neem oil @ 0.3 per cent or @ NSKE 5 per cent or petroleum oil-based agro spray @ 0.7 per cent.

Papaya Ring Spot Virus

- Remove and destroy the affected plants.
- Use tolerant variety, Pusa Majesty.
- Apply neem oil @ 0.3 per cent or @ NSKE 5 per cent or petroleum oil-based agro spray @ 0.7 per cent.

11. Harvesting

- Papaya is quick growing fruit plant. It starts flowering and fruiting in 5 months after planting and ripe fruits become ready for harvest in about 9-10 months after planting.
- The fruits should be left on tree until they fully mature as the fruits are non-climacteric in nature.
- In hills, from February to May because it requires warm climate during ripening. It was also observed that high relative humidity and comparatively high temperature during ripening period may not be conducive for development of attractive color of fruits which may retain pale green even when ripe.

Banana (*Musa* spp.)

1. Land preparation

- Soil should be well ploughed and all weeds should be removed.
- Pits of 2' x 2' x 2' (length, width and depth, respectively) are dug and refilled with the top 1' soil mixed with 20-25 kg of well-decomposed farmyard manure (FYM) or compost at least 15-20 days before actual planting.

2. Time of planting

- Normally banana plantation is done in June-July. Banana can also be planted in August-November or March-April.

3. Method of planting

- Pits of 60 cm x 60 cm x 60 cm size are dug, filled with mixture of soil and FYM (farmyard manure) in a 1:1 ratio. Suckers are planted in the centre of the pit and soil around is compacted. This is mostly followed in biennial plantations for Dwarf Cavendish, Rasthali, Robusta, Poovan and Karpuravalli banana.

- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Spacing

The spacing of banana crop is given below:

Spacing for dwarf varieties

1.2 m x 1.2 m (row-row x plant-plant)

1.8 m x 1.8 m (row-row x plant-plant)

2.0 m x 2.0 m (row-row x plant-plant)

Spacing for tall and semi-tall varieties

2.4 m x 1.8 m (row-row x plant-plant)

2.4 m x 2.4 m (row-row x plant-plant)

2.7 m x 3.0 m (row-row x plant-plant)

2.5 m x 2.5 m (row-row x plant-plant)

5. Aftercare

- ***De-suckering***

  Usually two suckers are retained per plant and the additional suckers are removed just below the ground level.

- ***Propping***

  Support is given to the bearing plant with the help of bamboo to protect them from bending down due to heavy bunch load and from any wind damage. Both tall as well as dwarf varieties require propping.

- ***Wrapping***

  Covering of bunches with polythene or gunny cloth that protects the fruits from intense heat causing sun-scald, hot wind *etc*., and improves the colour of the fruits.

- ***Earthing up***

  Earthing up is important particularly during rainy season; this prevents plants from waterlogging and also it will provide support to the base of the plant.

6. Cultivars/varieties

- Grand Naine (G-9), Dwarf Cavendish, Rasthali and Robusta

7. Organic nutrient management

- Banana responds well to both manure and fertilizers. The dosages of nutrient to be applied depend on the variety, initial soil fertility, climate *etc.* Basal dose of 25 kg FYM/pit should be applied and incorporated with the soil properly. FYM @ 20-25 kg/plant and/or vermicompost @ 5-10 kg/tree may be applied annually in two equal splits either sole or in combination for sustained optimum yield.
- Application of potash through biofertilizers (potash solubilizers) increases the number of hands/bunch and finger size, improves fruit quality, develops resistance to diseases and reduces water uptake in banana.
- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.
- Application of soil amendment such as dolomite @ 100-200 g/plant every second year is essential to maintain the soil pH.
- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

8. Water management

- Banana requires adequate soil moisture throughout the year. Irrigation is done just after planting, if there is no rain. Drip irrigation can reduce the quantity of water and increases yield, and decreases number of days to harvest. Water use efficiency is greater with drip irrigation as compared to basin system of irrigation, and the system *i.e.*, drip irrigation saves up to 50% of water used.
- Water-logging should not be allowed.

9. Weed management

- Banana plantation offers shade, therefore, it does not suffer too much from weed infestation. However, the crop should be free from weed growth to optimize the nutrient use efficiency.
- Manual weeding is the best method to check weed population. Shallow cultivation at early stages of crop is essential to control the weeds and provide better conditions for plant growth.

10. Mulching

- Banana crop responds to mulching. It decreases the cost of cultivation by reducing the number of irrigations and suppressing the weed growth. Generally, weed biomass and banana trash are abundantly available which can be used effectively.

11. Crop protection

Insect pests management

- Aphids, corm weevil, pseudo-stem borer and burrowing nematode are major insects in banana.
- Adopt clean cultivation using healthy and pest free suckers, drench the petioles, furled leaves, whorls or young suckers with soapy water or insecticidal soap for management of aphids. Apply bio-control agent, *Beauveria bassiana* in the banana fields.
- In case of corm weevil, practice clean cultivation with the suckers, periodically prune, remove and destroy infested clumps, crop rotation with non-host crops like rice and sugarcane, use of pheromone traps @ 16 traps /ha, and applying bio-control agents, *Beauveria bassiana* and *Metarhizium anisopliae* causes mortality of the weevils.
- Remove the pseudostem from ground level and destroy them in order to avoid it serving as breeding site for the pest for stem weevil management after harvest of the bunch,.
- Uproot and burn infested plants. Use longitudinal pseudostem traps @ 100/ha to trap weevils.

Disease management

Panama wilt of banana (*Fusarium oxysporum f. sp. cubensis*)

- Practice proper crop rotation with rice.
- Plant wilt resistant cultivars such as Poovan and Nendran in endemic areas.
- Remove and destroy affected plant reduces the spread of the disease.
- When only 1-3 plants are infected, kill and chop the diseased plants and strew all the material in water at a temperature of at least 70^{o}C for 30 minutes.
- Fertilization, irrigation, weed control also helps to manage the disease.

- Good drainage especially during rainy season should be provided.
- Soil application of rice chaffy grain or dried banana leaf formulation or well decomposed compost the plants.
- Provide mechanical barriers in and around the infected plants
- Bactericide, *Pseudomonas fluorescens @* 2.5 kg/ha can also be applied along with farmyard manure and neem cake.
- About 60 mg of *Pseudomonas fluorescens* (in a capsule) can be applied in a 10 cm deep hole made in the corm.
- Apply bio control agents like *Trichoderma viride* @ 25 g for 4 times once at planting in the pit and remaining doses at third, fifth and seventh month after planting.
- Application of neem cake @ 250 kg/ha was most effective.

Yellow sigatoka (*Mycospharella musicola*)

- Remove and destroy affected leaves.
- Keep the banana field weed free and timely removal of the suckers.
- Planting in close spacing should be avoided.
- Water-logging in the fields should be avoided.
- Spray Bordeaux mixture 1 per cent + linseed oil @ 2 per cent or copper oxychloride @ 0.25 per cent 10-15 days interval, from initial appearance of leaf specks on lower side of the leaf.

Bunchy Top (*Banana bunchy top virus*)

- Use virus free planting materials
- Remove and destroy affected plants.
- Spray plants with neem oil @ 0.3 per cent or @ NSKE 5 per cent or petroleum oil-based agro spray @ 0.7 per cent.

12. Harvesting

- Banana is a climacteric fruit and does not ripe early and uniformly on the plant, and hence, they are harvested when they are green and fully mature. It responds well to external ethylene application.

- The fruits are harvested when top leaves start drying and shed floral ends of the fruits with slightest touch of the end.
- The colour of the fruits changes from deep green to lighter green.
- The angles or ridges of the fruits become less prominent or they become round.
- Harvesting is performed by cutting the bunch while retaining 15-20 cm stalk; this helps in handling. Sometimes, partial harvesting is done when fruits are required for vegetable purposes.

Litchi (*Litchi chinensis* Sonn.)

1. Land preparation

- Litchi grows well on variety of soils including loam, sandy loam. The soil should be deep, well-drained and rich in organic matter. The soil should not have hard pan within 2.5 metres from the surface.
- Soil should be well ploughed and all weeds should be removed.
- Pits of 3' x 3' x 3' (length, width and depth, respectively) are dug and refilled with the top 1½' soil mixed with a basket full soil in a pit from a litchi orchard, containing mycorrhizal fungi and 20-25 kg of well-decomposed farmyard manure or compost at least 1-2 months before actual planting.

2. Time of planting

- Planting is done during early monsoon season in April-May in Sikkim.

3. Method of planting

- Litchi trees are planted generally in a square system with 10 m x 10 m spacing. Planting distance can be reduced to 7.5 m x 7.5 m where litchi plants need protection against from either frost or desiccating winds.
- Healthy 6 to 9 months old, true to the type plants, with fine roots should be selected for quick establishment and less mortality. It is advisable that all plants should be inoculated with mycorrhizal fungi.
- The rows should be oriented in north-south direction to maximize the use of sunlight.
- After planting the land should not be allowed to dry completely.

4. Cultivars/varieties

- Early Seedless (Early Bedana), Rose Scented, Shahi, Dehradun, Gulabi, Calcutta, Bombai, Late Seedless (Late Bedana), and China are important.

5. Organic nutrient management

- Litchi needs high amount of organic matter. The doses of manure applied may be as follows: 1-3 years age: 10-20 kg FYM/year/tree; 4-6 years age: 25-40 kg FYM/year/tree; 7-10 years age: 40-50 kg FYM/year/tree and > 10 years age: 60 kg FYM/year/tree may be applied annually in two equal splits.
- Micronutrients are essential for proper growth and fruiting in litchi and these can be applied through foliar sprays of water soluble organic sources @ 0.2 per cent.
- Application of soil amendment such as dolomite @ 100-200 g/plant in every second year is essential to maintain the soil pH.
- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

6. Intercropping

- Litchi is slow growing and takes at least six years to start bearing, vacant interspaces can be utilized for intercropping in early years.
- During summer and kharif season, vegetables like pumpkin, cucumber, ridge gourd, bitter gourd and leguminous crops may be grown. During winter season, crops like peas, bean, and grams can be grown.
- Besides vegetables, quick growing fruit crops like papaya, pineapple and banana can also be planted to optimize the use of interspaces. The inter crops should be manured separately and protected from pest and diseases.

7. Water management

- Adequate soil moisture is essential for the cultivation of litchi. Where annual rainfall is well distributed, litchi can be grown without irrigation. January-end to the onset of monsoon is critical period for irrigation since vegetative growth and fruit development takes place.
- Litchi is deep-rooted, perennial fruit crop, however, absorbing roots mostly occur in the uppermost soil layer between 20-30 cm depth. Therefore, this zone should have 50% soil moisture during the critical period.

- The fully grown trees are irrigated by flooding or by furrow irrigation, depending on the availability and source of irrigation. Depending on the availability of water, the orchard may be irrigated at fortnightly intervals in April and frequency may be increased further in May till the fruit is harvested.
- Sprinkler or drip irrigation system may be adopted to maximize the water-use-efficiency.

8. Weed management

- Manual weeding with the help of *khurpi* or hand hoe is the best pre-monsoon way to control the weed population.
- Hand-weeding should be done carefully to avoid injury to the roots.
- Ploughing, spading of basins, *etc.* are important inter-cultural operations for soil aeration and tree health.

9. Mulching

- Mulching is essential to avoid weed problem in the field during rainy season and for moisture conservation during winter season.
- Mostly, leaf mulch or weed biomass is recommended for mulching of litchi plantations. The best mulching material in Sikkim is *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*) which minimize some disease problems also.
- Weed growth can also be checked by mulching with black plastic mulch.

10. Crop protection

Insect pests management

- Erinose mite, bark eating caterpillar, litchi fruit borer and litchi leaf roller are some important pests of litchi.
- We should take preventive measures to avoid the infestation of mite. Layers should be prepared only from non-infested plants and the saplings should be sprayed with wettable sulphur before releasing from the nursery.
- The leaves should be checked regularly for symptoms over summer and autumn and the branches infested with the mite should be cut off and burnt.
- The damage caused by leaf rollers is tolerated as long as it is restricted to the foliage and unlikely to affect flower initiation. The rolled leaves that contain larvae may be removed manually during light infestation.

- Moths can be excluded by enclosing the fruit panicles in nylon mesh bags for fruit borer, but is uneconomic in areas with high labour costs. Use of *Trichogramma chilonis* @ 50,000 eggs/ha and use of pheromone traps can effectively manage the fruit borer.

Disease management

Brown blight (*Peronophythora litchi*)

- Remove shaded, infected and dead branches after harvest.
- Spray copper oxychloride @ 0.25% during winter and spring.

Anthracnose (*Botryodiplodia theobromae*)

- Avoid overcrowding of trees and branches in the orchard.
- Prune and burn the affected plants.
- Spray copper oxychloride @ 0.25%.
- Spray 3:3:50 Bordeaux mixture in February, April and September-October.

Tree decline and Root rot (*Phytophthora* spp., *Pythium* spp., *B. theobromae* and *Fusarium* spp.)

- Select propagating material from disease-free mother plant.
- Provide proper drainage.
- Prune the tree to reduce evaporation and encourage root growth to help the tree to recover quickly.
- Apply well-decomposed FYM.

Fruit rot

- Low temperature storage (5°C) is the most successful means of slowing rot development.

11. Harvesting

- Harvesting of litchi is usually done in May and June. Generally, litchi fruits take 50-60 days after fruit set. Colour development varies according to variety from light green to deep red to pinkish.

- Epicarp or skin becomes soft and smooth and tubercles becomes somewhat flattened at the tip.

- The fruits for local market should be harvested at their fully ripe stage, while for distant markets, when they start turning reddish. The fruits should be harvested at proper stage to possess good quality.

- Litchi fruits, like other fruits, are not harvested individually to avoid rupturing of skin at the stem-end and quick rotting of fruits. They are harvested in bunches along with portion of the bunch and few leaves. It prolongs the shelf life of fruits.

Kiwifruit (*Actinidia deliciosa*)

1. Land preparation

- Establishment of kiwifruit orchard requires site free from spring and early autumn frost with well-drained soil and relatively high atmospheric humidity.

- Rows should be oriented in north-south direction to maximise the use of sunlight.

- Pits of approximately 0.6 m x 0.6 m x 0.6 m size are dug in the month of September-October. The pit should be well-filled by adding 20-30 kg well-decomposed farmyard manure.

2. Time of planting

- Planting is done in the month of January when plants are dormant.

3. Method of planting

- The spacing varies with the cultivars and training system. In general, plant to plant spacing should be maintained at 4 to 5 meters from each other.

- The kiwifruit is dioecious *i.e.*, male and female flowers are borne on different vines. Care must be taken to plant male and female in the ratio of 1:8 to ensure proper pollination and fruiting of the well-grown orchard.

- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties

- *Female:* Monty, Bruno, Allison and Hayward

- *Male:* Tomuri, Allison male, Abott, Matua

5. Organic nutrient management

- Kiwifruit plants are heavy feeders of nitrogen which should be applied in abundance during the first half of the growing season through organic fertilizers.

- Apply well-decomposed and dried cattle manure or compost @ 10-40 t/ha from planting to peak fruit production age for sustained high yield and quality. This should be applied @ 25 to 100 kg/plant in two splits in Feb.-March and July-August.

- Neem cake @ 2 t/ha should be applied after vines have several inches of new growth during early spring. Gradually increase the amounts of manure applied each year until maturity.

- During active fruit growth stage, vermicompost @ 4 to 10 kg/plant should also be given for better growth, production and fruit quality.

6. Intercropping

- Commercial fruit bearing in kiwifruit orchard generally starts after 5 to 6 years until then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, French bean and leafy vegetables, root vegetables *etc.*

- Exhaustive crops *viz.,* maize, ginger *etc.* which drain the essential nutrients and moisture quickly from the field should be avoided as intercrops.

- Intercrops having high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. Water management

- Water requirement of kiwifruit orchard particularly during the first 2-3 years is very high for successful establishment. Subsequently, the foliage covering the entire surface area of the soil acts as mulch and reduces the frequency of irrigation.

- Overhead sprinklers are often used in commercial kiwifruit vineyards for frost protection as well as irrigation (sprinkler heads should be about 3 feet above the training wire).

- Drip irrigation, however, promotes more efficient use of water.

- Watering regularly in the heat of the summer is necessary at intervals of 10-15 days.
- In summer, newly planted vines should be watered deeply about once a week. Never allow a plant to undergo drought stress.

8. Weed management and mulching

- Weeding is done just before manure application and mulching. Two-three weeding is required depending on the intensity of weed growth.
- Natural weed cover itself helps in the conservation of soil and organic matter. However, the basin of vine should be cleaned regularly and mulched to conserve soil moisture.
- The best mulching material in Sikkim is *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*) which minimize disease incidence also.

9. Training and pruning

- In the first year, the vine is headed back at 30-40 cm distance from the ground and single apical bud is allowed to grow up to the wire. This will be the main trunk. No further branching on the main trunk is permitted.
- In the second year, two shoots are selected and tied down at both sides to the middle wire. These are the secondary arms.
- In the third year, the tertiary fruiting arms which bear fruits in the coming years are selected on these secondary arms.
- These tertiary arms should be tied down to the out trigger wire to hold them in position. The first crop forms on these laterals and develops on them or on replacement of fruiting arms. Fruiting arms should not be trained along the out trigger wires parallel to the permanent leaders because the shoots from these will compete with fruiting arms which originate directly from the leader causing dense growth, which adversely affects the management and vine growth.
- Kiwifruit flowers and bears fruit on wood that has grown from the previous season’s growth. Dormant pruning of female vines begins by heading back last years’ fruiting canes to 10-12 buds past the last fruit. Small, weak wood should be heavily pruned to force new vigorous canes. Avoid pruning in early spring after the plant growth has begun; excess bleeding can occur and may damage the plant.

10. Crop protection

Insect pests management

No major pest has so far been reported on kiwifruit plant. Leaf roller, Greedy scale and two spotted spider mite may damage the crop to limited extent. Two sprays of neem oil (1500 ppm) @ 3 ml/l at 15 days interval are found to be effective against leaf roller. Greedy scale and two-spotted spider mite can be managed by spraying petroleum-based agro spray @ 10 ml/l and wettable sulphur @ 0.25% at 15 days interval, respectively.

Disease management

1. Root rot, Collar rot, Crown rot (*Phytophthora coctorum*, *P. cinnamoni, P. citricola, P. lateralis, P. megasperma*)

- Disinfect the planting material by root dip treatment with Bordeaux mixture (1.0 per cent) or copper oxychloride @ 0.25 per cent before planting.
- Drench soil with Bordeaux mixture @ 1 per cent or copper oxychloride @ 0.25 per cent.
- Sites with good drainage should be selected to establish new orchards.

2. **Bacterial leaf blight** and **Blossom blight** (*Pseudomonas viridiflava*)

- General field sanitation and pruning of diseased parts helps in checking the disease.
- Drench soil with Bordeaux mixture @ 1 per cent or copper oxychloride @ 0.25 per cent.

11. Harvesting

- Kiwifruit is an exception in which no perceptible change either in skin or flesh colour occurs. Flavour and aroma do not develop because the fruit is harvested hard.
- Maturity index of 6.2 per cent of total soluble solids or more has been established and found very satisfactory for fruit harvest.
- Under Sikkim conditions, the fruit is harvested from first week of November. The kiwifruits are still hard when harvested by snapping their stalks easily at an abscission layer found at peduncle attachment.
- After harvest, the fruits are rubbed with coarse cloth or shaken in gunny bag to remove the stiff hair present on the skin surface.

Pear (*Pyrus* spp.)

1. Land preparation

- Establishment of pear orchard requires site free from spring and early autumn frost with well drained soil and relatively high atmospheric humidity.
- Soil should be well ploughed and all weeds should be removed.
- Pits of approximately 2.0' x 2.0' x 2.0' size are dug during October-November. The pit should be well-filled by adding 10-20 kg well-decomposed farmyard manure.

2. Time of planting

- In Sikkim, planting of dormant plant should be done in the last week of January to first week of February.

3. Method of planting

- The plant spacing varies with the cultivars and training system. In general, plant to plant spacing should be maintained at 4 m x 4 m on terraces or in contour system of plantation.
- Care must be taken to plant pollenizer cultivars in the orchard to ensure proper pollination and fruiting of the well-grown orchard.
- Rows should be oriented in north-south direction to maximize the use of sunlight.
- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties

- *Asian type for lower to mid hills*: Punjab Beauty, Punjab Nectar, Punjab Gold, China, Tumaria, LeConte, Kieffer *etc.*
- *Japanese type for mid hills*: Hosui, Kosui, Sojuru, Shinsui *etc.*
- *European type for high hills*: Bartlett, Red Bartlett, D Anjou, Doyenne du Comice, Victoria, Bagugosha *etc.*

5. Organic nutrient management

- Pear requires adequate nutrients for good vegetative growth and yield. Well-decomposed and dried cattle manure or compost @ 15-20 t/ha should be applied at the time of planting or during the dormant stage of plants.

- Neem cake @ 2 t/ha should be applied after pear has attained several inches of new growth during early spring.
- During active fruit growth stage, vermicompost @ 2 kg/plant should also be given for better fruit growth and production.
- Mulching with manure and/or straw is very beneficial. However, do not place the mulch directly in contact with the pear plant as crown rot may occur.

6. Intercropping

- Commercial fruit bearing in pear orchard generally starts after 4 to 5 years until then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, French bean, and cole crops, leafy vegetables, root vegetables *etc*.
- Exhaustive crops *viz.,* maize, ginger *etc.,* which drain the essential nutrients and moisture quickly from the field should be avoided as intercrops.
- Intercrops with high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. Water management

- The requirement of water particularly during the first 2-3 years is very high for successful establishment of pear orchard. In summer, newly planted pears should be watered deeply about once a week. Never allow plants to undergo drought stress.
- In hills, pear cultivation is mostly done under rainfed conditions but at many places irrigation facility may be available which is an additional advantage. Besides rain fall, 75-100 cm irrigation may be applied annually in some regions.
- Both excessive and scanty moisture affects color, composition and keeping quality of fruits, therefore, drip irrigation is beneficial.
- After harvesting in July-August, the trees should be irrigated at 20 days interval or so up to the end of October. Thereafter, no irrigation is required up to January except when the manure and organic fertilizers are applied in December.

8. Weed management and mulching

- The basin of pear plant should be cleaned regularly and mulched to conserve the soil moisture. Weeding is done just before manure application and mulching. Two or three weeding is required depending on the intensity of weed growth.

- The best mulching material in Sikkim is *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*) which minimize disease incidence also.

9. Training and pruning

- The most common system of training pear is modified central leader, where one branch is allowed to grow vertically and form the main bole upon which scaffold limbs are spaced at selected intervals.
- Majority of pruning in pear is done during deep dormancy season and also at the planting time for newly planted trees.
- Young and juvenile trees should be pruned carefully for the purpose of training to bring in the desired shape.
- Pruning severity depends on the growth habit of the cultivar and the management practices recommended for the crop. Bearing and older trees are pruned with much care and in timely manner to balance vegetative growth and fruit production.

10. Crop protection

Insect pests management

- Aphids, Codling moth, Pear psylla and Oriental fruit fly are some important pests of pear.
- When numbers of aphids are low they can be squashed by hand.
- Collect and destroy infested fruits.
- Orchard sanitation is very important to prevent pest infestation.
- Two sprays of petroleum oil-based agro spray @ 10 ml/l or neem formulation (1500 ppm) @ 3 ml/l at 20 days interval are effective for management of aphids, psylla and Codling moth.
- Para pheromone trap can be used to catch the male adults of fruit fly.

Disease management

Fire blight (*Erwinia amylovera*)

- Field sanitation, collection and burning of diseased leaves, pruning of diseased shoots or branches help in managing the disease.

- Excise and destroy overwintering cankers or twig infections before the blossoms open.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

11. Harvesting

- European pears are harvested when ‘firm mature’ and stored immediately, and then allowed to ripen for several days prior to fresh consumption. When fully ripe, European pears have the typical ‘melting’ flesh texture, and full development of flavor.
- Asian pears, however, are harvested closer to physiological ripeness and placed in cold storage.
- Pears for marketing are picked by hand several times over a 10-20 day period.

Walnut (*Juglans regia* L.)

1. Land preparation

- Establishment of walnut orchard requires site free from frost in spring and extreme heat in summer with well drained soil.
- Soil should be well ploughed and all weeds should be removed.
- Pits of approximately 3.0' x 3.0' x 3.0' size are dug during November. The pit should be well-filled by adding 20-25 kg well-decomposed farmyard manure.

2. Time of planting

- In Sikkim, planting of dormant plant should be done in the last week of January-beginning of February.

3. Method of planting

- The plant spacing varies with the cultivars and training system. In general, plant to plant spacing should be maintained at 10 m x 10 m on terraces in contour system of plantation.
- Rows should be oriented in north-south direction to maximize the use of sunlight.
- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties

- CITH-17, Kagzi, Lake English *etc.*

5. Organic nutrient management

- Walnut requires adequate nutrients for good vegetative growth and yield. Well-decomposed and dried cattle manure or compost @ 20-25 t/ha should be applied at time of planting or during the dormant stage of plants.
- Neem cake @ 2 t/ha should be applied after walnut has attained several inches of new growth during early spring.
- During active growth stage, vermicompost @ 2-4 kg/plant should also be given for better fruit growth and production.
- Mulching with manures and/or straws is very beneficial. However, do not put the mulch directly in contact with the plant as crown rot may occur.

6. Intercropping

- Commercial fruit bearing in walnut orchard generally starts after 6 to 8 years until then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, garlic, French bean, and cole crops, leafy vegetables, root vegetables *etc.*
- Exhaustive crops *viz.*, maize, ginger *etc.* which drain the essential nutrients and moisture quickly from the field should be avoided for intercropping.

7. Water management

- The requirement of water particularly during the first 2-3 years is very high for successful establishment of orchard.
- In hills, walnut cultivation is mostly done under rainfed conditions; however, drip irrigation is beneficial.
- After harvest in September-October, the trees should be irrigated once. Afterwards no irrigation is required up to January except when the manure and organic fertilizers are applied in December.

8. Weed management and mulching

- The basin of walnut plant should be cleaned regularly and mulched to conserve the soil moisture. Weeding is done just before manure application and mulching. Two or three weeding is required depending on the intensity of weed growth.

- In Sikkim, mulching can be done with *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*) which minimize disease incidence also.

9. Training and pruning

- The most common system of training walnut is modified central leader.
- Young and juvenile trees should be pruned carefully for the purpose of training to produce the desired shape.
- Pruning severity depends on the bearing habit of the cultivar. In terminal bearing cultivars, pruning consists of heading back of selected framework of branches and thinning out competing limbs.
- The lateral bearing cultivars are both thinned and headed back heavily in order to encourage shoot growth which gets suppressed due to earlier fruit production.

10. Crop protection

Insect pests management

- Codling Moth, Walnut Husk Fly, Walnut Aphid, Two spotted Mite are major insects.
- When number of aphids are low, they can be squashed by hand.
- Orchard sanitation is very important to prevent pest infestation.
- Two sprays of petroleum oil-based agro spray @ 10 ml/l or neem formulation (1500 ppm) @ 3 ml/l at 20 days interval are effective for management of aphids psylla, two spotted mite Walnut husk fly and Codling moth.

Disease management

*Walnut blight (*Xanthomonas campestris *pv.* juglandis*)*

- Apply copper containing bactericides such as Bordeaux mixture @ 1 per cent.
- Bactericides should be applied weekly to protect new growth during periods of wet weather.

*Phytophthora root and crown rot (*Phytophthora *spp.)*

- Plant trees in well-drained soils.

- Drainage can be improved by leveling soil or installing drainage systems.
- Avoid wetting tree trunks when irrigating.
- Graft union should be several centimeters above the soil line when planting trees.
- Use resistant rootstocks.
- Drench with Bordeaux mixture @ 1 per cent or copper oxychloride @ 0.25 per cent.

Armillaria root rot (Oak root fungus) (Armillaria mellea)

- Armillaria root rot cannot be effectively controlled once it is established in an orchard.
- Diseased or dead plants should be uprooted and removed.
- Planting resistant rootstocks is the most effective method to prevent the disease.
- Use tolerant rootstocks.
- Saving the infected trees: Remove soil from the base down to a depth of 9 to 12'' in spring. Keep the crown and upper roots exposed to air and avoid wetting them for the duration of the growing season. Refill the soil before rains start.

Black-line disease (Cherry leaf roll virus (CLRV-W)

- Use virus-free graft and bud-wood.
- Remove and destroy trees identified as being infected.

Crown gall (Agrobacterium tumefaciens)

- Plant disease-free nursery stock.
- Plant trees in well-drained soils.
- Avoid wounding the plants as much as possible.
- Fresh wounds can be treated with bio-control agent (*Agrobacterium tumefaciens* K84), if available, to prevent the bacterium from colonizing.

11. Harvesting

- Walnut is mostly harvested in month of September and October. Some nuts fall down naturally after hulling in a natural way, rest have to be harvested by manual picking or beating with long poles.

- Pre-harvest treatment with ethylene @ 200-300 ppm at packing tissue brown (PTB) stage proved better to induce early and uniform hull dehiscence in walnut.

Pomegranate (*Punica granatum* L.)

1. Land preparation

- Soil should be well ploughed and all weeds should be removed. In heavy soils, ridges should be prepared to have better aeration of the root system in order to obtain higher production.

- Pits of 2' x 2' x 2' (length, width and depth, respectively) are dug and refilled with the top 1' soil mixed with 15-20 kg well-decomposed farmyard manure or compost at least 1-2 months before actual planting.

2. Time of planting

- In Sikkim, January-February planting is suggested.

3. Method of planting

- Pomegranate is planted at a distance of 4 m x 4 m on terraces in contour system of plantation.

- The rows should be oriented in north-south direction to maximize the use of sunlight.

- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars

- Bhagwa (Sinduri), Kandhari, Mridula, Ganesh, Bedana *etc.*

5. Organic nutrient management

- Pomegranate plants should be manured twice a year *i.e.*, June-July and December-January.

- FYM @ 15-25 kg/tree and/or vermicompost @ 4.5-9 kg/tree may be applied annually in two equal splits either sole or in combination for sustained optimum yield.

- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.

- Micronutrients are essential for proper growth and fruiting in pomegranate and these can be applied through foliar sprays of water soluble organic sources @ 0.2 per cent.

- Application of soil amendment such as dolomite @ 100-200 g/plant every second year is essential to maintain the soil pH.
- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pests and diseases.

6. Intercropping

- Commercial fruit bearing generally starts after 3 to 5 years; till then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, garlic, and leafy vegetables, root vegetables *etc.*
- Intercrops having high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. Water management

- Pomegranate should be watered just after planting in the absence of rains.
- Irrigation during January-February helps in getting good vegetative flush.
- Irrigation improves plant growth, flowering and fruiting in pomegranate.
- Irrigation is given to make the soil root zone moist; thus, heavy irrigation is unnecessary. However, drip system of irrigation shall be best for harvesting quality fruits and conservation of water during winter months.

8. Weed management

- Manual weeding with the help of *khurpi* or hand hoe is the best pre-monsoon method to control the weed population.
- Hand-weeding should be done carefully to avoid injury to the roots.
- Ploughing, spading of basins, *etc.* are important inter-cultural operations for soil aeration and tree health.

9. Training and pruning

- Generally, pomegranate tree will have few trunks 3-5 in modern orchards. The trees are trained to grow as an open vase. In such a way that light penetrates the trees from between the rows as well as from the inside of the trees.

- If the main trunks are bent too much, binding them with strong material to the opposite side branches is undertaken.
- Trees should be pruned to check overcrowding in the orchard.
- In order to achieve the desired shape trees are pruned in winter, some care is also taken during summer. In winter, pruning the height of the trees is reversed to the desired height.
- Broken, bent, and interfering branches are removed. In order to keep the interior of the tree open during growing season, and according to need, summer pruning is done.

10. Mulching

- Mulching is essential to avoid weed problem in the field during rainy season and moisture conservation during winter season.
- Mostly, leaf mulch is recommended for mulching of pomegranate plantations. The best mulching material in Sikkim is *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*), which minimize some disease problems also.
- Weed growth can also be checked by mulching with black plastic mulch.

11. Crop protection

Insect pests management

- Fruit borer, thrips and bark eating caterpillar are some important pests of pomegranate.
- Remove and destroy the affected fruits for management of fruit borer.
- Bag the fruits with butter paper before maturity.
- At flowering stage, spray neem oil (1500 ppm) @ 3 ml/l at 15 days interval.
- Do not inter-cultivate crops like chilli and onion for thrips; remove and destroy affected plant parts.
- Use blue sticky traps @ 1 trap/10 plants.
- Maintain orchard sanitation by avoiding overcrowding of trees. Clean the cobwebs around the affected portion and inject kerosene oil into the holes and seal with mud.

Disease management

Wilt (*Ceratocystis fimbriata*, *Fusarium oxysporum*)

- Adequate drainage should be provided.

Cercospora leaf and fruit spot (*Cercospora punicae*)

- Prune and destroy affected branches.
- Diseased fruits should be collected and destroyed.
- Spray copper oxychloride @ 0.3 per cent.

Bacterial blight (*Xanthomonas oxynopodis* pv. *punicae*)

- Provide wide row spacing.
- Prune the affected branches and burn.
- Select disease-free plants.
- Spray copper oxychloride @ 0.25 per cent or calcium chloride @ 1.5 per cent.
- Variety Wonderful is resistant to bacterial blight.

Alternaria fruit spot (*Alternaria alternata*)

- All the affected fruits should be collected and destroyed.
- Protective spraying with copper oxychloride @ 0.25 per cent is recommended.

Anthracnose (*Colletotrichum gloeosporioides*)

- Protective spraying with copper oxychloride @ 0.25 per cent or wettable sulphur 0.3 per cent is recommended.

12. Harvesting

- Pomegranate fruits are harvested when rind attains the desired colour.
- The fruits are clipped off from the stalk with a pair of sharp scissors. Harvesting is generally done at weekly interval.

Insect pests

Brassica spp.

Mustard aphid

Saw fly

Painted bug

Maize (*Zea mays*)

Army worm

Cob borer

Finger millet (*Elusine coracana*)

Pink stem borer

Soybean (*Glycine max*)

Leaf roller

Rice (*Oryza sativa*)

White ear due to stem borer

Dead heart due to stem borer

Leaf folder damage

Gundhi bug

Dragon fly

Spider

Chilli peppers (*Capsicum* spp.)

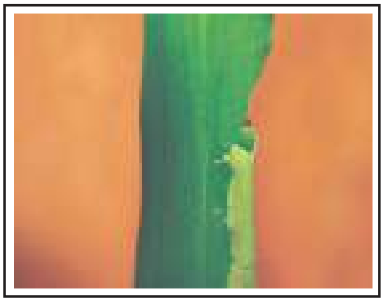
Fruit borer damage

Chilli aphid

Tea mosquito bug

Ginger (*Zingiber officinale*)

Shoot borer



Leaf roller

White grub damage

Tomato (*Lycopersicon esculentum*)

White fly

Fruit borer

Pheromone trap for trapping adult of fruit borers

Large cardamom (*Ammomum subulatum*)

Leaf caterpillar

Okra (*Abelmoschus esculentus*)

Blister beetle

Mandarin (*Citrus reticulata*)


Trunk borer damage


Bark eating caterpillar


Shoot borer


Aphid


Leaf miner


Mealy bug


Huanglongbing


Lemon butterfly

Cole crops (*Brassica* spp.)

Cabbage butterfly

Cabbage semi-looper

Diamond black moth

Cabbage aphid

Diseases of foodgrain crops

Diseases of Rice

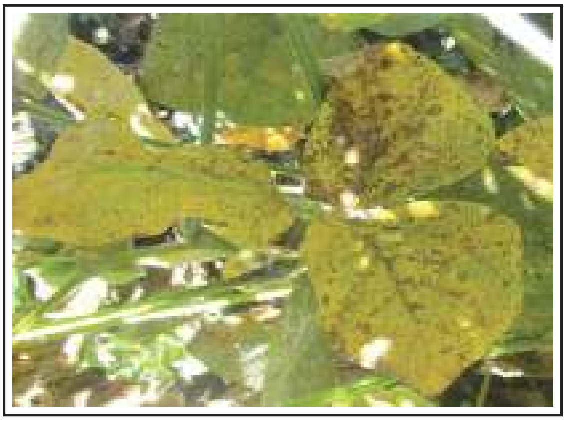
Blast

Brown spot

Sheath blight

Bacterial leaf blight

Disease of Soybean



Rust

Powdery mildew

Diseases of Blackgram

Anthracnose

Yellow mosiac

Leaf crinkle

Rust

Powdery mildew

Diseases of Mustard

Anthracnose

Yellow mosiac

Leaf crinkle

Disease of Maize

Turcicum leaf blight

Maydis leaf blight

Disease of Fingermillet

Blast

Diseases of horticulture crops

Disease of Cole crops

Club root

Damping off

Black rot

Disease of Tomato


Early blight


Late blight


Bacterial wilt


Damping off


Mosaic


Laef curl

Disease of Cucurbits


Powdery mildew


Downey mildew

Disease of Pea

Powdery mildew

Rust

Disease of Potato

Late blight

Early blight

Disease of Capsicum and Chilli


Anthracnose

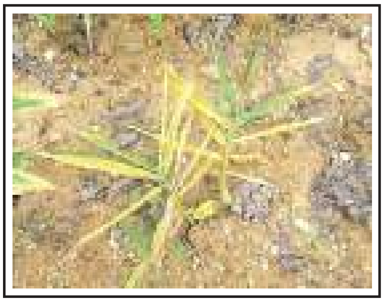

Cercospora leaf spot


Phytophthora root rot


Leaf curl


Mosaic

Disease of Ginger


Soft rot


Bacterial wilt


Dry rot

TAMIL NADU

Suggested cropping systems (based on testing under NPOF)

1. Green manure-cotton-maize
2. Green manure-chillies-sunflower
3. Green manure-beetroot-maize

Details of crops in Cropping Systems

Cotton

Particulars	*Kharif*
Crop	Cotton
Sowing/planting	August 1st fortnight
Harvesting	January 2nd fortnight
Variety	Suraj

Important features of suitable varieties

Varieties	MCU 12	Suraj
Duration (days)	160	165
Average yield under organic condition (kg/ha)	2000 kg/ha	1799 kg/ha
Source (s) of availability	TNAU, Coimbatore	CICR, Coimbatore
Suitable regions/districts in the state	Coimbatore, Erode, Madurai, Dindigul, Theni, Dharmapuri, Salem, Namakkal, Erode	Coimbatore

Field preparation: Prepare the field to get a fine tilth. Chiselling for soils with hard pan: Chisel the soils having hard pan formation at shallow depths with chisel plough at 0.5 metre interval, first in one direction and then in the direction perpendicular to the previous one, once in three years. Form ridges and furrows 10 m long with 60 cm spacing by using ridge plough or bund former.

Cultural practices

Seed rate (kg/ha)	7.5 kgs of delinted seeds		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azospirillum	600 g/ha	Seed treatment
	Phosphobacteria	600 g/ha	Seed treatment
	Pseudomonas	10 g/kg of seed	Seed treatment
	Trichoderma	4 g/kg of seed	Seed treatment
Spacing (row x plant)	60 x 30 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	7.05 tonnes	
	Vermicompost	4.49 tonnes	
	Azospirillum	2 kg	
	Phosphobacteria	2 kg	
	Pseudomonas	2.5 kg	
	Trichoderma	2.5 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Vermicompost	1 t/ha	45 DAS
	Panchagavya	3% spray	30, 60 and 90 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	15-18 irrigations depending on the weather and soil type	Germination phase (1-15 days) Vegetative phase (16-44 days) Flowering phase (85-90 days)	
Major weeds	*Acalypha indica*, *Cyanodon dactylon*, *Cyperus rotundus*, *Digera arvensis*,*Chloris barbata*, *Trianthema portulacastrum*, *Parthenium hysterophorus*		

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Vegetative and flowering phase	Manual weedingStubble mulching	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Fruit borer: Helicoverpa armigera	Application of Nuclear Polyhedrosis Virus (NPV) in evening hours at 7th and (12th week after sowing • Beauveria bassiana • Release of egg parasitoid, Trichogramma spp., • Egg-larval parasitoid, Chelonus blackburnii and Predator Chrysoperla carnea • ULV spray of NPV, for effective control of Helicoverpa	3 x 10^{12} POB /ha 1.15% WP 400 g/ha 6.25 cc/ha at 15 days interval 3 times from 45 DAS1,00,000/ha at 6th, 13th and 14th week after sowing. 3 x 10^{12} POB /ha with 10% cotton seed kernel extract, with sticking agent
	Pink bollworm: *Pectinophora gossypiella*	• Use pheromone trap to monitor the adult moth activity • Three weekly releases of egg parasitoid Trichogramma sp	(@1,00,000/ha per release
	Cotton Stem Weevil: Pempheres **(**Pempherulus) affinis and **Shoot weevil:** Alcidodes affaber	Basal application of neem cake	250 kg/ha
	Tobacco Cutworm: Spodoptera litura	• Use of light trap • Growing castor along border and irrigation bunds	

	• Removal and destruction of egg masses • Removal and destruction of early stage larvae • Hand picking and destruction of grown up caterpillars	
Sucking pests	• Neem oil • Neem seed kernel extract • Fish oil rosin soap • Notchi leaf extract Catharanthus rosea extract	3% 5% 2.5% 5% 5%
Foliar diseases - Alternaria leaf spot: Alternaria macrospora	Neem oil Bacillus subtilis	3% 0.04% on 60, 90 and 120 days after sowing
Wilt : Fusarium oxysporum f. sp. vasinfectum	• Seed treatment with Trichoderma viride formulation • Destroy the infected - plant debris. • Soil application of Trichoderma viride	4g/kg seed 2.5kg/ha
Root Rot: Rhizoctonia bataticola	• Seed treatment with T. viride • Seed treatment with Bacillus • Soil application • Seed treatment with Pseudomonas • Soil application of Pseudomonas	@ 4 g/kg seed @ 10g/kg seed @ 2.5 kg/ ha at the time of sowing @10g/kg @ 2.5 kg/ha at the time of sowing

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Mean**
Economic yield (kg/ha)	1323	1460	1175	1493	1515	1053	1165	1312

Maize

Important features of suitable varieties

Varieties	**CO1**	**COH(M)6**
Duration (days)	10-110	110
Average yield under organic condition (kg/ha)	5200	7400
Source (s) of availability	TNAU	TNAU
Suitable regions/districts in the state	Coimbatore, Erode, Tirunelveli, Tanjore and Pudukottai	All maize growing areas
Specific resistance / tolerance to disease	Resistant to downy mildew Orange flint grains	Multiple disease resistance to Sorghum downy mildew, Maydis leaf blight, Turcicum leaf blight, Post flowering stock rot and Banded leaf and sheath blight

Field preparation: Plough the field with disc plough once followed by cultivator ploughing twice, after spreading FYM or compost till a fine tilth is obtained. Form ridges and furrows providing sufficient irrigation channels. The ridges should be 6 m long and 60 cm apart using a bund former or ridge plough.

Cultural practices

Seed rate	20 kg/ha			
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**		**Method of application**
	Azospirillum	600 g/ha		Seed treatment
	Phosphobacteria	600 g/ha		Seed treatment
Spacing (row x plant) in cm	60 x 25 cm			
Basal application of organic manures	**Source**		**Quantity/ha**	
	FYM		11.88 tonnes	
	Vermicompost		7.57 tonnes	
	Azospirillum		2 kg	
	Phosphobacteria		2 kg	

Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Vermicompost	1 tonnes	30 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	9 to 11 irrigations based on the weather and soil type	Germination & establishment phase-1 to 14 days Vegetative phase - 15 to 39 days Flowering phase - 40 to 65 days Maturity phase - 66 to 95 days	-
Major weeds	*Acalypha indica*, *Cyanodon dactylon*, *Cyperus rotundus*, *Digera arvensis*,*Chloris barbata*, *Trianthema portulacastrum*, *Parthenium hysterophorus*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	• Vegetative phase Flowering phase	• Manual weeding • Stubble mulching	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Stem borer: *Chilo partellus*	Release egg p[arasitoid Trichogramma chilonis are desirable. Third release is to be accompanied with larval parasitoid Cotesia flavipes @ 5000/ha	@2,50,000 /ha (three releases at weekly interval)
	Corn worm/ Earworm: *H elicoverpa armigera*	• Set up of light traps • Set up sex pheromone traps • Two applications of NPV along with crude sugar 2.5 kg + cotton	@ 12/ha @ 1.5 x 10^{12} POB at 10 days interval along with crude sugar 2.5 kg +

		seed kernel powder 250 g on the ear heads	cotton seed kernel powder 250 g on the ear heads
	Sucking pests	Neem oil Neem seed kernel extract Fish oil rosin soap	3%
	Foliar diseases	Neem oil	3%
Optimum stage of harvesting	• The sheath covering the cob will turn yellow and dry at maturity. • The seeds become fairly hard and dry.		

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	3753	4123	4078	3757	4064	4144	5481	4200

Chillies

Particulars	Kharif
Crop	Chillies
Sowing/planting	August 1rst fortnight
Harvesting	February 1rst fortnight
Variety	PKM1

Important features of suitable varieties

Varieties	PKM1	K1
Duration (days)	180	210
Average yield under organic condition (kg/ha)	3.08 tonnes/ha – dry pod	1.8 tonnes/ha- dry pod
Source (s) of availability	TNAU	TNAU
Suitable regions/districts in the state	Rainfed and irrigated conditions	Southern Districts of Tamil Nadu, Coimbatore

Nursery raising practices

Seed rate

Varieties: 1.0 kg / ha.

Nursery area: 100 sq. m/ha

Nursery raising: Protray nursery

- Mix sterilized cocopeat @ 300 kg with 5 kg neem cake along with Azospirillum and phosphobacteria each @ 1 kg. Approximately 1.2 kg of cocopeat is required for filling one protay. 300 protrays (98 cells) are required for the production of 29,000 seedlings, which are required for one hectare adopting a spacing of 90 x 60 x 45 cm in a paired row system.
- Sow the seeds in protrays @ 1 seed per cell.
- Cover the seed with cocopeat and keep the trays one above the other and cover with a polythene sheet till germination starts.
- After 6 days place the protrays with germinated seedlings individually on the raised beds inside the shade net.
- Water with rosecan everyday upto seed germination.

Field preparation: Thoroughly prepare the field and form ridges and furrows at a spacing of 60 cm. Irrigate the furrows and transplant 40-45 days old seedlings, with the ball of earth on the ridges.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azospirillum	400 g/ha	Seedling root dip
	Phosphobacteria	400 g/ha	Seedling root dip
Spacing (row x plant) in cm	60 x 45 cm		
Number of seedlings/hill	2		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	7.50 tonnes	
	Vermicompost	3.09 tonnes	
	Azospirillum	2 kg	
	Phosphobacteria	2 kg	
	Pseudomonas	2.5 kg	

	Trichoderma	2.5 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Vermicompost	1 tonnes	45 DAS
	Panchagavya	3% spray	30, 60, 90 and 120 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	18-24 irrigations depending on the weather and soil type	Irrigation is done at weekly intervals	-
Major weeds	*Acalypha indica, Cyanodon dactylon, Cyperus rotundus, Digera arvensis,Chloris barbata, Trianthema portulacastrum, Parthenium hysterophorus*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Vegetative and flowering phase	Hand weeding once in 30 days after planting.	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Fruit borer	• Set up pheromone traps for Helicoverpa armigera or Spodoptera litura • Collection and destruction of damaged fruits and grown up caterpillars.	@ 12 Nos./ha.
		• Spray Bacillus thuringiensis	@ 2 g/lit
	Sucking pests	Neem oil	3%
		Neem seed kernel extract	5%
	Damping off and anthracnose	• Seed treatment with Trichoderma viride or	@ 4 g/kg

	Pseudomonas fluorescens	@ 10 g/kg
	• Soil application of Pseudomonas fluorescens	@ 2.5 kg/ha
	• Neem oil	@ 3%

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	3168	5345	3153	5526	5812	4483	6215	4815

Sunflower

Important features of suitable varieties

Varieties	TNAU Sunflower Hybrid CO 2	COSFV 5
Duration (days)	90-95	85-90
Average yield under organic condition (kg/ha)	2250	1700
Source (s) of availability	TNAU, Coimbatore	TNAU, Coimbatore
Suitable regions/districts in the state	Coimbatore, Erode, Salem, Namakkal, Tirunelveli, Dindigul, Dharmapuri, Tiruchirapalli, Perambalur, Karur, Cuddalore, Villupuram, Virudhunagar, Sivagangai , Ramanathapuram, Madurai, Theni, Thoothukudi,	Coimbatore, Erode, Salem, Namakkal, Tirunelveli, Dindigul, Dharmapuri, Tiruchirapalli, Perambalur, Karur, Cuddalore, Villupuram, Virudhunagar, Sivagangai , Ramanathapuram, Madurai, Theni, Thoothukudi

Field preparation: Plough once with tractor or twice with iron-plough or three to four times with country-plough till all the clods are broken and a fine tilth is obtained. Spread 12.5 t/ha of FYM or compost or composted coir pith evenly on the field before the last ploughing and incorporate in the soil by working with a country plough. Form ridges and furrows 6 m long. Use bund-former or ridge plough to economise and form irrigation channels across and ridges according to the topography of the field.

Cultural practices

Seed rate	6 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Azospirillum	600 g/ha	Seed treatment
	Phosphobacteria	600 g/ha	Seed treatment
	Trichoderma	4g/kg	Seed treatment
Spacing (row x plant) in cm	45 cm x 30cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	5.30 tonnes	
	Vermicompost	3.37 tonnes	
	Azospirillum	2 kg	
	Phosphobacteria	2 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Vermicompost	500 kg	30 DAS
	Panchagavya	3%	30, 45 and 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	10-12 irrigation depending on the weather and soil type	Seeding, flowering and seed development stage	-
Major weeds	*Acalypha indica, Cyanodon dactylon, Cyperus rotundus, Digera arvensis,Chloris barbata, Trianthema portulacastrum, Parthenium hysterophorus*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Vegetative phase Flowering phase	Manual weeding Stubble mulching	

Organic plant protection practices	Name of pest/ disease	Organic material recommended for control	Quantity
	Capitulum borer (Head borer): *Helicoverpa armigera*	- Sow trap crops like marigold at 50 plants/acre	
		- Use of pheromone traps for pest intensity identification as well as to trap the male moths	4 traps/acre
		- Setting of light traps to know the range of pest incidence as well as to kill moth population	
		- Release predators like coccinellids, Chrysoperla carnea	1 light trap/ 5 acre
		- Release parasitoides like Trichogramma spp, (Bracon spp., Campoletis spp)	@1larva/ head
		- Spraying of 5% Neem oil or 5% Neem Seed Kernal extract before egg laying	@ 20,000/acre
	Bihar hairy caterpillar: Spilosoma oblique	- Deep summer ploughing - Use of well rotten manures - Collection and destruction of larvae	
	Tobacco caterpillar: *Spodoptera litura*	- Hand pick the Helicoverpa larvae and destroy - Install bird perches per hectare for predatory birds	

	Leaf hopper (jassids): *Amrasca biguttula biguttula*	• Neem oil • Neem seed kernel extract	3% 5%
	Foliar diseases	Neem oil	3%
	Charcoal Rot: *Macrophomina phaseolina*	Soil application of P. fluorescens or T. viride	2.5 kg / ha + 50 Kg of well decomposed FYM or sand at 30 days after sowing
Optimum stage of harvesting	Observe the bracts on the backside of the capitula. When they turn lemon yellow, the heads harden and the crop is ready for harvest.		

Yield

Year	1st	2nd	3rd	4th	5th	6th	7th	Mean
Economic yield (kg/ha)	1252	1227	1023	1349	1602	1304	1373	1304

Beetroot

Particulars	Kharif
Crop	Beetroot
Sowing/planting	July 1st fortnight
Harvesting	September 2nd fortnight
Variety	Ruby queen

Important features of suitable variety

Variety	Ruby queen
Duration (days)	60-75 days
Source (s) of availability	Private industry
Suitable regions/districts in the state	Widely adaptable (Preferably cool weather)

Field preparation: Land is ploughed to a fine tilth by thorough ploughing making it loose and friable. Clods are to be removed completely. Apply well decomposed farmyard manure at the time of final ploughing.

Cultural practices

Seed rate (kg/ha)	6 kg/ha		
Spacing (row x plant) in cm	30 x 10 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	3.75 t/ha	
	Vermicompost	1.55 t/ha	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Vermicompost	500 kg	45 DAS
	Panchagavya	3% spray	30, 45 and 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	8 - 10 irrigations depending on the weather and soil type	Irrigation is done at weekly intervals	
Major weeds	*Acalypha indica, Cyanodon dactylon, Cyperus rotundus, Digera arvensis,Chloris barbata, Trianthema portulacastrum, Parthenium hysterophorus*		
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	Early stage of crop growth	Hand weeding once in 30 days after sowing	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Leaf miners, web worms, semi loopers	Neem oil	3%
	Cercospora leaf spot	Neem oil	3%

Yield

Economic yield (kg/ha)	24.8 t/ha

Sunhemp

Important features of suitable variety

Crop	Sunnhemp
Duration (days)	150 days
Average yield under organic condition (kg/ha)	Green biomass – 13-15 t/ha
Source (s) of availability	TNAU
Suitable regions/districts in the state	All districts of Tamil Nadu

Field preparation: Plough the soil to fine tilth, broadcast the seeds and form ridges and furrows 60 cm.

Cultural practices

Seed rate (kg/ha)	30 kg/ha for green manure		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium	1 kg/ha	Seed treatment
Spacing (row x plant) in cm	Broadcasted		
Irrigation practices	Once in 30 days		
Organic plant protection practices	Neem oil: 3% spraying		
Optimum stage of harvesting	Incorporation during flowering stage or 45 DAS		

Yield: Incorporated as green biomass on 45 DAS


Cotton under organic system


Maize crop under the biodynamic farming practices

UTTAR PRADESH

Suggested cropping system (based on testing under NPOF)

1. Basmati rice-wheat-*sesbania* green manure
2. Rice (coarse) -barley+mustard-greengram
3. Maize (grain)-potato-okra
4. Maize (green cobs)-mustard+radish-*sesbania* green manure

Basmati rice

Particulars	*Kharif*
Crop	Basmati rice
Sowing/planting	First fortnight of July
Harvesting	First fortnight of November
Variety	Basmati-370

Important features of suitable varieties

Varieties	Basmati-370	Pusa Basmati- 6	Pusa Basmati- 2
Duration (days)	145-150	150-155	120
Average yield under organic condition (kg/ha)	3142	4300	3700
Suitable regions/districts in the state	Haryana and western Uttar Pradesh	Punjab, Haryana, western Uttar Pradesh and Uttarakhand	Punjab, Haryana, Delhi, Western Uttar Pradesh and Uttarakhand

Nursery raising practices

Area of nursery required for 1 ha	100 m^2
Nursery raising method	Wet nursery
Seed sowing rate/m^2	250 g (25 kg/ha)

Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2 area**	**Method of application**
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma-harzianum	4 g/kg seed	
Source and optimum quantity of organic manures/other	**Materials**	**Quantity/ m^2area**	**Method of application**
Nutrient source/m^2 of nursery	FYM	2 kg	Soil incorporation
	Vermicompost	1 kg	Top dressing at 15 DAS
Irrigation practices	Keep saturated the soil for initial 5 days and gradually increase water up to 5 cm		
Weed management	One hand weeding at 15 DAS		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/ m^2area**
	Seed borne diseases	Solar seed treatment	For 2 hrs. during mid day after pre-soaking in water for 2 hrs.
	Soil borne diseases	Seed & seedling treatment with *Pseudomonas fluorescence* & *Trichoderma harzianum*	*Pseudomonas* @ 10 g/kg seed &*Trichoderma* @ 4 g/kg seed
Optimum age of nursery	25 days		

Field preparation: First, incorporation of green manure should be done by two cross harrowing at least 20 days before transplanting. After incorporation, a heavy irrigation should be done which helps in decomposition of debris of green manure. Around 15 days after green manure incorporation, sufficient water should be applied in the field for puddling. Before puddling, about 30 cm high earthen bunds should be made around the field. Puddle the field around 3-4 runs of puddler in standing water. After one or two days of puddling, divide the field in to narrow beds of 1.25 meter width and of any convenient length and transplanting should be done in 3-5 cm standing water.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pseudomonas fluorescence	2.5 kg/ha	Seedling treatment
	Trichoderma harzianum	5 kg/ha	Soil application
Spacing (row x plant) in cm	20 x 10		
Number of seedlings/hill	2		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	12 tonnes	
	Azotobactor	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	4.84 tonnes	30 days after transplanting
	Panchagavvya	15 litres	Spray twice at 45 and 60 days after transplanting
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	10	Panicle initiation, flowering	5 (intermittent submergence)
Major weeds	**Local name**	**English name**	**Scientific name**
	Grasses		
	Makra ghas	Crow foot grass	*Dactyloctenium aegyptium*
	Takri	Crabgrass	*Digitaria ciliaris*
	Sewai/Sawa	Barnyardgrass	*Echinochloa colona*
	Samak/Sawa	Common barnyard grass	*Echinochloa crusgalli*

	Jharnpriya kodu	Indian Goose grass	*Eleusine indica*
	Kangni	Yellow foxtail	*Setaria glauca*
	Broad leaf weeds		
	Kalmua/Kalmi saag/Karemu	Morningglories	*Ipomoea aquatica*
	Agni Booti	Blistering ammania	*Ammannia bassifera*
	Kankaua	Dayflower	*Commelina benghalensis*
	Sedges		
	Motha	Rice sedge	*Cyprus* spp.
	Jhirua	Grass like Fimbry	*Fimbristylis miliacea*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 days after transplanting	Hand weeding	
	60 days after transplanting	Hand weeding	
		Continuous water stagnation till jointing stage	
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material/ practices used for control**	**Quantity/ Practices/ Details**
	Diseases		
	Seed borne diseases (Bacterial leaf blight, brown spot, blast, sheath blight)	Seed treatment with hot water	At 52^{0}C for 15-20 minutes
		Seed treatment with *Pseudomonas fluorescence* and/ or *Trichoderma* spp. Before sowing (after hot water treatment)	10g/kg seed

		Seedling dip for 2 hrs with *Pseudomonas fluorescence* and/or *Trichoderma* spp. Before transplanting	10g/L water
	Soil borne diseases	Soil application of *Pseudomonas fluorescence* and /or *Trichoderma harzianum*	5 kg/ha
		Growing nursery in soil solarized seed beds	
	Bacterial leaf blight, sheath blight and blast	Foliar spray of *Pseudomonas fluorescence* and/or *Trichoderma* spp. at tillering, mid crop and panicle emergence stage.	10g/L water (1000 L suspension/ha)
	Blast	Early sowing	By end of June to first week of July
		Foliar spray of cow urine extract	10% (two sprays at 10 days interval after appearance of disease)
	Brown spot	Provide proper nutrition to crop	Apply recommended NPK through organic manure
	Sheath blight	Foliar spray with *Pseudomonas fluorescence* and/ or *Trichoderma* spp. at tillering, mid crop and panicle emergence stage.	10g/L water (1000 L suspension/ha)

		Destruction of alternative weeds host from border and within the crops	
	Bacterial leaf blight	Removal of water from field for few days immediately after appearance of the symptoms	
	Root knot nematode	Soil application of *Trichoderma harzianum*	5 kg/ha
		Grow nursery in soil solarized seed beds	
	Insect pests		
	Stem Borer/ leaf folder	Pruning of leaf tip in nursery before transplanting	
		Release of *Trichogramma* (Trichocards)- egg parasitoid in standing crop based on monitoring of pest population through light traps	50000 parasitized eggs/ha (5-6 releases)
	Leaf eating caterpillars/ leaf folders	Foliar spray of Ginger-chilli-garlic extract	Crush 10 kg garlic, 5 kg ginger and 5 kg green chilli in 70 L water. Apply extract @60L/ha
	Foliar pests	Foliar spray of cow dung-cow urine-neem leaf extract	Spray two days fermented extract of 2L cow urine, 1kg cow dung and 2kg crushed neem leaves in 1000L water.

	Gundhi bug	Foliar application of garlic + green chillies paste	The extract of 2.5 kg garlic + 2.5 kg green pungent chillies paste + 500 g neem leaves + 500g ginger/ha sprayed during milky stage of rice.

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**Mean**
Economic yield (kg/ha)	2450	2818	3560	3740	3142

Organic Basmati rice

Organic basmati rice vegetative stage

Wheat

Particulars	Details
Crop	Wheat
Sowing time	Second fortnight of November
Harvesting time	First fortnight of April
Varieties	PBW-343, PBW 373, UP 2526

Important features of suitable varieties

Varieties	PBW-343	PBW 373	UP 2526
Duration (days)	130	130	135
Average yield under organic condition (kg/ha)	3547		
Source (s) of availability	NSC	NSC, PAU	NSC
Suitable regions/districts/ state	Punjab, Haryana, Delhi, western Uttar Pradesh	Western Uttar Pradesh	Western Uttar Pradesh
Specific resistance / tolerance to disease	Resistant to stripe rust, leaf rust, karnal bunt	Resistant to stripe rust, leaf rust, karnal bunt	Loose smut, Karnal bunt, stripe rust, stem rust, leaf rust

Field preparation: Due to short turn around period after basmati rice, the field should be immediately irrigated after rice harvest. After around 10 days when field comes in condition, the FYM should be applied and the field should be ploughed 2-3 times with disc or mouldboard plough. After ploughing, two cross tilling with tines should be done each followed by planking. To ensure good germination, sowing should be done after 1-2 days of completion of field preparation.

Cultural practices

Seed rate (kg/ha)	100		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Solar seed treatment		For 2 hrs. during mid-day after pre-soaking in water for 2 hrs.
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma harzianum	4 g/kg seed	Seed treatment

Spacing (row x plant) in cm	20 x 5		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	12 tonnes	
	Azotobactor	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	4.84 tonnes	30 DAS
	Panchagavvya	15 litres	Spray twice at 45 and 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	6	Crown root initiation, jointing, milking	5
Major weeds (give local, english and scientific name)	**Local name**	**English name**	**Scientific name**
	Grasses		
	Jangali Jai	Wild oat	*Avena fatua*
	Gullidanda/ Baluri	Littleseed canary grass	*Phalaris minor*
	Daub ghas	Bermudagrass	*Cynodon dactylon*
	-	Bluegrass	*Poa annua*
	Broad leaf weeds		
	Jangli Berseem	Wild colver	*Trifolium spp.*
	Lunia	Common purslane	*Portulaca oleracea*
	Kateli	Creeping thistle	*Circium arvense*
	Bathua	Lamb's-quarters	*Chenopodium album*
	Hirankhuri	Field Bindweed	*Convolvulus arvensis*
	Peeli Senji	Yellow sweet clover	*Melilotus indica*
	Krishna neel	Blue Pimpernel	*Anagallis arvensis*
	Gajri	Fineleaf fumitory	*Fumaria paviflora*
	Sedges		
	Motha	Nut Grass	*Cyprus rotundus*

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**
	30 DAS	1. Hand weeding
	45 DAS	2. Hand weeding
		3. Stale seed bed
		4. Higher plant stand

Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Diseases		
	Leaf blight	Zero tillage reduces the survival of pathogen in soil	
		Seed treatment with *Pseudomonas fluorescence* or *Trichoderma harzianum*	5kg/ha before sowing
		Hot water treatment of seeds	At 52^{0}C for 10 min.
		Soil application of *Pseudomonas fluorescence* or *Trichoderma harzianum*	5kg/ha before sowing
		Foliar spraying of *Pseudomonas fluorescence* or *Trichoderma harzianum*	5g/L at mid crop stage
	Loose smut	Solar heat treatment of seeds before sowing	soaking of seeds in water for 4 hrs followed by 8 hrs drying in clear sunny days in the month of June
	Rusts	Grow resistant varieties	
		Foliar spraying of sour buttermilk	5 L buttermilk diluted in 200 L water (1000 L solution for 1ha)

	Karnal bunt	Grow resistant varieties	
		Avoid excessive irrigation during ear formation	
		Foliar spraying of mustard-milk extract	1Kg mustard flour mixed in 5L milk and 100L water/ha at the time of flowering
	Ear cockle or seed gall	Use healthy seeds, mechanical or physical cleaning of seeds	Dip the seeds in 20% brine solution and remove floating seed galls
		Hot water seed treatment	At 54^{0}C for 10 Min.
	Insect-Pests		
	Aphids	Spray of neem oil or neem – seed – kernel -extract	At 3% or 5% concentration, respectively, if aphid population observed
	Termite	Soil application of *Beauveria bassiana*	5kg/ha before sowing
		Application of neem leaf manure (5q/ha) or neem seed manure (1q/ha)	Before sowing
		Apply only fully decomposed organic manures in the field	
	Army worm	Foliar spray of neem leaf extract	5% (5kg neem leaf crushed in 100L boiled water and diluted to 100L)
	Rats	Flour baits mixed with cement powder	-

Yield

Year	1st	2nd	3rd	4th	Mean
Economic yield (kg/ha)	2662	3125	4070	4330	3547

Sesbania green manure

Field preparation: After wheat harvest, the field should be immediately irrigated. When field comes in condition field should be prepared by two cross harrowing followed by two planking to ensure proper levelling. Sowing of *Dhaincha* (*Sesbania*) is done by broadcasting the seeds in field followed by irrigation.

Cultural practices

Seed rate (kg/ha)	20		
Spacing method	By broadcasting		
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	At the interval of 15 days	5
Weed management	Not required		
Optimum stage of incorporation	45 days after sowing		

Yield

Year	1st	2nd	Mean
Biomass production (kg/ha) on dry weight basis	5240	5110	5180

Green manure incorporation

Sesbania green manure

Coarse rice

Particulars	***Kharif***
Crop	Coarse rice
Sowing/planting	First fortnight of July
Harvesting	Second fortnight of October
Variety	Saket-4

Important features of suitable variety

Variety	**Saket-4**
Duration (days)	110-120
Average yield under organic condition (kg/ha)	3926
Suitable regions/districts/state	Uttar Pradesh, Bihar and Jammu & Kashmir
Specific resistance / tolerance to pest	Moderately resistant to green leaf hopper and stem borer
Specific resistance / tolerance to disease	Moderately resistant to bacterial leaf blight
Specific tolerance to drought/waterlogging	Resistant to lodging

Nursery raising practices

Area of nursery required for 1 ha	100 m^2		
Nursery raising method	Wet nursery		
Seed sowing rate/m^2	250 g (25 kg/ha)		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2 area**	**Method of application**
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma-harzianum	4 g/kg seed	Seed treatment
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^{2}area**	**Method of application**
	FYM	2 kg	Soil incorporation

	Vermicompost	1 kg	Top dressing at 15 DAS
Irrigation practices	Keep saturated the soil for initial 5 days and gradually increase water up to 5 cm		
Weed management	One hand weeding at 15 DAS		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity**
	Seed borne diseases	Solar seed treatment	For 2 hrs. during mid-day after pre-soaking in water for 2 hrs.
	Soil borne diseases	Seed treatment with *Pseudomonas fluorescence* & *Trichoderma harzianum*	*Pseudomonas* @ 10 g/kg seed &*Trichoderma* @ 4 g/kg seed
Optimum age of nursery	25 days		

Field preparation: Before preparation field should be irrigated thoroughly. When it comes in condition, the FYM should be applied and the field should be ploughed 2-3 times with disc or mouldboard plough followed by two cross tilling with tines and planking. Around 4-5 days before transplanting, sufficient water should be applied in the field for puddling by making about 30 cm high earthen bunds around the field. Pudddle the field around 3-4 runs of puddler in standing water. After one or two days of pudling, divide the field in to narrow beds of 1.25 meter width and of any convenient length and transplanting should be done in 3-5 cm standing water.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	Material	Recommended rate	Method of application
	Pseudomonas fluorescence	2.5 kg/ha	Seedling treatment
	Trichoderma harzianum	5 kg/ha	Seedling treatment
Spacing (row x plant) in cm	20 x 10		

Number of seedlings/hill	2		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	12 tonnes	
	Azotobacter	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	4.84 tonnes	30 days after transplanting
	Panchagavvya	15 litres	Spray twice at 45 and 60 days after transplanting
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	10	Panicle initiation, flowering	5 (intermittent submergence)
Major weeds	**Local name**	**English name**	**Scientific name**
	Grasses		
	Makra ghas	Crow foot grass	*Dactyloctenium aegyptium*
	Takri	Crabgrass	*Digitaria ciliaris*
	Sewai/Sawa	Barnyardgrass	*Echinochloa colona*
	Samak/Sawa	Common barnyard grass	*Echinochloa crusgalli*
		Chinese sprangletop	*Leptochloa chinensis*
	Jharnpriya kodu	Indian Goose grass	*Eleusine indica*
	Kangni	Yellow foxtail	*Setaria glauca*
	Broad leaf weeds		
	Kalmua/Kalmi saag/Karemu	Morningglories	*Ipomoea aquatica*
	Agni Booti	Blistering ammania	*Ammannia bassifera*
	Kankaua	Dayflower	*Commelina benghalensis*
		Water primrose	*Ludwigia* spp.

	Sedges		
	Motha	Rice sedge	*Cyprus* spp.
	Jhirua	Grass like Fimbry	*Fimbristylis miliacea*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 days after transplanting	Hand weeding	
	60 days after transplanting	Hand weeding	
		Continuous water stagnation till jointing stage	
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material/ practices used for control**	**Quantity**
	Diseases		
	Seed borne diseases (Bacterial leaf blight, brown spot, blast, sheath blight)	Seed treatment with hot water	At 52^{0}C for 15-20 minutes
		Seed treatment with *Pseudomonas fluorescence and Trichoderma* spp. before sowing (after hot water treatment)	*Pseudomonas fluorescence* @ 10 g/kg seed and *Trichoderma* spp. 10 g/kg seed
		Seedling dip for 2 hrs with *Pseudomonas fluorescence* and/ or *Trichoderma* spp. before transplanting	10g/L water
	Soil borne diseases	Soil application of *Pseudomonas fluorescence* and /or *Trichoderma harzianum*	5 kg/ha

		Growing nursery in soil solarized seed beds	
	Bacterial leaf blight, sheath blight and blast	Foliar spray with *Pseudomonas fluorescence* and/or *Trichoderma* spp. at tillering, mid crop and panicle emergence stage.	10g/L water (1000 L suspension/ha)
	Blast	Early sowing	By end of June to first week of July
		Foliar spray of cow urine extract	10% (two sprays at 10 days interval after appearance of disease)
	Brown spot	Provide proper nutrition to crop	Apply recommended NPK through organic manure
	Sheath blight	Foliar spray with *Pseudomonas fluorescence* and/or *Trichoderma* spp. at tillering, mid crop and panicle emergence stage.	10g/L water (1000 L suspension/ha)
		Destruction of alternative host weeds from borders and within the crops	
	Bacterial leaf blight	Removal of water from field for few days immediately after appearance of the symptoms	
	Root knot nematode	Soil application of *Trichoderma harzianum*	5 kg/ha

		Grow nursery in soil solarized seed beds	
	Insect pests		
	Stem borer/ leaf folder	Pruning of leaf tip in nursery before transplanting	
		Release of *Trichogramma* (Trichocards)- egg parasitoid in standing crop based on monitoring of pest population through light traps	50000 parasitized eggs/ha (5-6 releases)
	Leaf eating caterpillars/leaf folders	Foliar spray of Ginger-chilli-garlic extract	Crush 10 kg garlic, 5 kg ginger and 5 kg green chilli in 70 L water. Apply extract @60L/ha
	Foliar pests	Foliar spray of cow dung-cow urine-neem leaf extract	Spray two days fermented extract of 2L cow urine, 1kg cow dung and 2kg crushed neem leaves in 1000L water.
	Gundhi bug	Foliar application of garlic + green chillies paste	The extract of 2.5 kg garlic + 2.5 kg green pungent chillies paste + 500 g neem leaves + 500g ginger/ha sprayed during milky stage of rice.

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**Mean**
Economic yield (kg/ha)	3100	3875	4260	4470	3926

Barley + mustard (4:1)

Particulars	Details
Crop (s)	Barley + Mustard
Sowing time	First fortnight of November
Harvesting time	Second fortnight of March
Varieties	Barley (Azad, DWRB-91), Mustard (Pusa Bold)

Important features of suitable varieties

Varieties	Barley		Mustard
	Azad	DWRB-91	Pusa Bold
Duration (days)	115-120	115	140
Average yield under organic condition (kg/ha)	4000	3800	1000
Source (s) of availability	CSA, University of Agriculture & Technology, Kanpur (UP)	DWR Karnal	IARI, New Delhi
Suitable regions/districts/ state	saline-alkaline soils of Uttar Pradesh, Bihar and West Bengal		All India

Field preparation: Due to short turn around period after rice, the field should be immediately irrigated after rice harvest. After around 10 days when field comes in condition, the FYM should be applied and the field should be ploughed 2-3 times with disc or mouldboard plough. After ploughing, two cross tilling with tines and 2-3 planking should be done. To ensure good germination, sowing should be done after 1-2 days of completion of field preparation.

Cultural practices

Seed rate (kg/ha)	80		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Solar seed treatment	For 2 hrs.	For 2 hrs. during mid-day after pre-soaking in water for 2 hrs.

	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma harzianum	4 g/kg seed	Seed treatment
Spacing (row x plant) in cm	20 x 5		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	8 tonnes	
	Azotobactor	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	3.22 tonnes	30 DAS
	Panchagavvya	15 litres	Spray twice at 45 and 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	4	Active tillering, flowering	5
Major weeds	**Local name**	**English name**	**Scientific name**
	Grasses		
	Jangali Jai	Wild oat	*Avena fatua*
	Gullidanda/ Baluri	Littleseed canary grass	*Phalaris minor*
	Daub ghas	Bermudagrass	*Cynodon dactylon*
		Bluegrass	*Poa annua*
	Broad leaf weeds		
	Jangli Berseem	Wild colver	*Trifolium spp.*
	Lunia	Common purslane	*Portulaca oleracea*
	Kateli	Creeping thistle	*Circium arvense*
	Bathua	Lamb's-quarters	*Chenopodium album*
	Hirankhuri	Field Bindweed	*Convolvulus arvensis*

	Peeli Senji	Yellow sweet clover	*Melilotus indica*
	Krishna neel	Blue Pimpernel	*Anagallis arvensis*
	Gajri	Fineleaf fumitory	*Fumaria paviflora*
	Sedges		
	Motha	Nut Grass	*Cyprus rotundus*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
		Hand weeding	
		Hand weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Diseases		
	Covered smut of barley	Use of certified seeds and resistant variety	
		Crop rotation	
		Hot water treatment of seeds before sowing	At 52^{0}C for 11 Min.
	Rusts	Grow resistant varieties only	
		Foliar spraying of sour butter milk	5 L diluted in 200L water (1000 L solution for 1ha)
	Stripe disease	Use of certified seeds and resistant variety	
		Crop rotation	
		Hot water treatment of seeds before sowing	At 52^{0}C for 11Min.
	Insect-Pests		
	Termite	Soil application of *Beauveria bassiana*	5kg/ha before sowing

		Application of neem leaf manure (5q/ha) or neem seed manure (1q/ha)	Before sowing
		Apply only well decomposed organic manures in the field	
	Army worm	Foliar spray of neem leaf extract	5% (5kg neem leaf crushed in 100L boiled water and diluted to 100L)
	Rats	Flour baits mixed with cement powder	

Yield

Year	1st	2nd	Mean
Economic yield (kg/ha) Barley + Mustard	2560+385	2830+334	2695+360

Barley + mustard intercropping

Mustard under organic condition

Green gram

Particulars	Details
Crop	Green gram
Sowing time	Second fortnight of April
Harvesting time	First fortnight of June
Varieties	Pusa Vishal, Pant Moong-1, Pant Moong-2

Important features of suitable varieties

Varieties	Pusa Vishal	Pant Moong-1	Pant Moong-2
Duration (days)	65-70	65-75 days	60-65
Average yield under organic condition (kg/ha)	735		
Source (s) of availability	IARI, New Delhi		
Suitable regions/districts/ state	Punjab, Haryana, Western Uttar Pradesh, Rajasthan, J&K and Plains of Himanchal Pradesh		
Specific resistance / tolerance to pest	Tolerant to jassids and white fly		
Specific resistance / tolerance to disease	Resistant to yellow vein mosaic	Resistant to yellow mosaic virus	Resistant to yellow mosaic virus
Specific tolerance to drought / waterlogging		Resistant to shattering	

Field preparation: For summer season, a pre-irrigation immediately after harvesting of *Rabi* crop should be given. When the field comes in condition, prepare it by giving 2-3 cross harrowing followed by planking to make the field levelled.

Cultural practices

Seed rate (kg/ha)	15		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Rhizobium	25 g/ Kg Seed	Seed treatment
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma harzianum	4 g/kg seed	Seed treatment

Spacing (row x plant) in cm	30 x 10		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	4 tonnes	
	PSB	10 kg	
	Trichoderma	5 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	1.61 tonnes	30 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Flowering and pod formation	5
Major weeds	**Local name**	**English name**	**Scientific name**
	Daubghas	Bermooda grass	*Cynodon dactylon*
	Motha	Nut grass	*Cyprus rotundus*
	Patharchatta	Horse purslane	*Trianthema portulacastrum*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 DAS	Hand weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Yellow mosaic disease	Control of whitefly vectors by spray of neem oil or neem-seed-kernel-extract	At 3% or 5% concentration, respectively if, whitefly population observed
	Leaf eating insects	Spray of neem oil or neem-seed-kernel-extract	At 3% or 5% concentration, respectively, if, leaf damage observed

Yield

Year	1st	2nd	3rd	4th	Mean
Economic yield (kg/ha)	976	208	871	886	735

Maize (grain)

Particulars	*Kharif*
Crop	Maize
Sowing/planting	First fortnight of July
Harvesting	First fortnight of October
Varieties	Star-56, PMH-3, PMH-4

Important features of suitable varieties

Varieties	Star-56	PMH-3	PMH-4
Duration (days)	90-95	95 -100	
Average yield under organic condition (kg/ha)	7380	6200	6000
Source (s) of availability	Private sector variety	DRMR, New Delhi	DRMR, New Delhi
Suitable regions/districts in the state	North Western India	Delhi, Punjab, Haryana and Western Uttar Pradesh	Delhi, Punjab, Haryana, Uttar Pradesh and Uttrakhand
Specific resistance / tolerance to pest		Resistance to Maydis	
Specific resistance / tolerance to disease		Resistance to leaf blight, erwinia stalk rot	Resistant against MLB, BLSB, BSDM and PFSR

Field preparation: The first ploughing should be done by 2-3 cross harrowing for the proper incorporation of okra debris in to soil. Then the field should be irrigated for proper decomposition of okra debris and ensuring proper moisture for maize germination. When the field comes in condition, 2 cross harrowing followed by two cross tilling with cultivators or should be done. After that 1-2 planking should be done to ensure proper levelling. For sowing maize broad beds of 60 cm width should be made with the help of soil shaper.

Cultural practices

Seed rate (kg/ha)	20		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma harzianum	4 g/kg seed	Seed treatment
Spacing (row x plant) in cm	60 x 20		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	10 tonnes	
	Azotobactor	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	4.0 tonnes	30 DAS
	Panchagavya	15 litres	Spray twice at 45 and 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Silking, tasseling	5
Major weeds	**Local name**	**English name**	**Scientific name**
	Grasses		
	Makra ghas	Crow foot grass	*Dactyloctenium aegyptium*
	Sewai/Sawa	Barnyard grass	*Echinochloa colonum*
	Samak/Sawa	Common barnyard grass	*Echinochloa crusgali*
	Takri	Crabgrass	*Digitaria ciliaris*
	Doobghas	Barmuda grass	*Cynodon dactylon*

	Banchari	Johnson grass	*Sorghum helepanse*
	Broad leaf weeds		
	Baridhudi	Hairy spurge	*Euphorbia hirta*
	Chouli	Pig weed	*Amaranthus viridis*
	Pattharchatta	Horse purslane	*Trianthima portulacastrum*
	Lalmurga	Cockscomb,	*Celosia argentia*
	Kankoua	Dayflower	*Commelina benghalensis*
	Hulhul/Chilmil	Hurricane weed	*Phylanthus niruri*
	Makoi	Black nightshade	*Solanum nigrum*
	Lunia	Purslane	*Portulaca oleraceae*
	Sedges		
	Motha	Purple nutsedge	*Cyprus rotundus*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30 DAS	Hand weeding	
	50 DAS	Hand weeding	
		Stale seed bed	
Organic plant protection practices	**Name of pest / disease**	**Organic material recommended for control**	**Quantity**
	Diseases		
	Soil borne diseases	Seed & seedling treatment with *Pseudomonas fluorescence* & *Trichoderma harzianum*	*Pseudomonas* @ 10 g/kg seed & *Trichoderma* @ 4 g/kg seed
	Leaf spot/blight	• Crop rotation • Deep summer ploughing	

		• Clean cultivation	
	Rust	Foliar spraying of sour buttermilk	5 L diluted in 200L water (1000 L solution for 1ha)
	Banded leaf and sheath blight	Foliar spraying of *Pseudomonas fluorescence* and/or *Trichoderma harzianum*	Two sprays at 10 days interval after appearance of symptoms @5g/L water
	Insect-Pests		
	1. Maize Stem borer	Release of *Tricogramma chilonis* (Tricho-cards)	Tricho-cards @ 1 lakh parasitized eggs/ha at 10 days intervals 5-6 times

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	4380	4860	4590	4610

Organic maize

Organic maize cobs

Potato

Particulars	**Details**
Crop	Potato
Sowing time	Second fortnight of October
Harvesting time	First fortnight of March
Varieties	Chipsona-2, Chipsona-3, Kufri Pukhraj, Kufri Ashoka, Kufri Chandramukhi

Important features of suitable varieties

Varieties	**Mid duration**		**Early**		
	Chipsona-2	**Chipsona-3**	**Kufri Pukhraj**	**Kufri Ashoka**	**Kufri Chandramukhi**
Duration (days)	90-110		70-90	70-80	80-90
Average yield under organic condition (kg/ha)		32400			
Source (s) of availability	CPRI, Shimla	CPRI, Shimla	CPRI, Shimla	CPRI, Shimla	CPRI, Shimla
Suitable regions/ districts in the state	North Indian plains	North Indian plains	Bihar, Gujarat, Haryana, Himachal Pradesh, Uttar Pradesh, Punjab, West Bengal		Bihar, Gujarat, Haryana, Himachal Pradesh, Uttar Pradesh, Punjab, West Bengal
Specific resistance / tolerance to disease	Resistant to late blight, immune to wart	Resistant to late blight	Resistant to early blight and moderately resistant to late	Tolerant to late blight	Tolerant to many diseases

Field preparation: To ensure fine and well pulverized seed bed for potato, field should be ploughed twice 20-25 cm deep with disc plough followed by two cross harrowing. After harrowing, the field should be cross tilled twice with tine cultivator each followed by planking. After field preparation, ridges are made in the field 60 cm apart with the help of ridger.

Cultural practices

Seed rate (kg/ha)	2500		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Solar seed treatment	For 2 hrs.	For 2 hrs. during mid-day after pre-soaking in water for 2 hrs.
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma harzianum	4 g/kg seed	Seed treatment
Spacing (row x plant) in cm	60 x 20		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	15 tonnes	
	Azotobacter	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	6.0 tonnes	30 DAS
	Panchagavya	15 litres	Spray twice at 45 and 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	8	Tuber initiation to tuber maturity	5
Major weeds	**Local name**	**English name**	**Scientific name**
	Grasses		
	Jangali Jai	Wild oat	*Avena fatua*
	Gullidanda/ Baluri	Littleseed canary grass	*Phalaris minor*
	Daub ghas	Bermudagrass	*Cynodon dactylon*
	Poa ghas	Bluegrass	*Poa annua*

	Broad leaf weeds		
	Jangli Berseem	Wild colver	*Trifolium spp.*
	Lunia	Common purslane	*Portulaca oleracea*
	Kateli	Canada Thistle	*Circium arvense*
	Bathua	Lambsquarters	*Chenopodium album*
	Hirankhuri	Field Bindweed	*Convolvulus arvensis*
	Senji	Sweetclover	*Melilotus indica*
	Dudhi	Sowthistle	*Sonchus* spp.
	Jangali palak	Broadleaf dock	*Rumex obtusifolius*
	Sedges		
	Motha	Nut Grass	*Cyprus rotundus*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30 DAS	Hand weeding	
	50 DAS	Hand weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material practices recommended for control**	**Quantity**
	Diseases		
	Early blight	• Use of healthy seeds • Crop rotation • Provide proper nutrition to plant • Removal and burning of infested plant debris • Summer deep tillage • Avoid irrigation in cool cloudy weather • Foliar spraying of *Pseudomonas fluorescence* and *Bacillus subtilis*	5g/L water (1000L solution/ha)
	Late blight	• Use resistant varieties	-

		• Proper drainage in the field • Sowing of healthy seeds • Early planting can avoid the disease	
	Black scurf and stem canker disease	Seed/tuber treatment with *Pseudomonas fluorescence* & *Trichoderma harzianum*	*Pseudomonas* @ 10 g/kg tuber &*Trichoderma* @ 4 g/kg seed
		Soil application of *Pseudomonas fluorescence* & *Trichoderma harzianum*	5 kg/ha in 100 kg precolonized well decomposed FYM
		Mulching of soil with rice husk (2-3cm) or polyethylene sheet	
	Virus diseases	Use virus free healthy seeds Rouging of infected plants	
		Control of aphid vectors by foliar application of neem oil or neem-seed-kernel-extract	At 3% or 5% concentration, respectively if, aphid population observed
		Dehaulming at least 15 days before harvesting	
	Insect-Pests		
	Aphids	Foliar application of neem oil or neem-seed-kernel-extract	At 3% or 5% concentration, respectively, if aphid populations observed
	Cutworms	Use of light traps and soil application of *Beauveria bassiana* before sowing	5kg/ha

White grubs	• Deep summer ploughing • Install light traps in April-May • Soil application of *Beauveria bassiana* or *Metarrhizium anisoplae* before sowing	 5kg/ha precolonized in 100kg FYM
4. Nematodes	Soil application of *Pseudomonas fluorescence* and/ or *Trichoderma harzianum*	10kg/ha precolozized in well rotten FYM

Yield

Year	**1st**	**2nd**	**3rd**	**4th**	**Mean**
Economic yield (kg/ha)	9430	12083	21300	22300	16278

Organic potato var. Chiopsona- 3

Organic potato var. Chiopsona- 3

Okra

Particulars	Details
Crop	Okra
Sowing time	Second fortnight of March
Harvesting time	Second fortnight of June
Variety	Arka Anamika

Important features of suitable variety

Variety	Arka Anamika
Duration (days)	130-135
Average yield under organic condition (kg/ha)	10405
Source (s) of availability	IIHR, Bangalore
Specific resistance / tolerance to disease	Yellow vein mosaic resistant

Field preparation: In the loose field left after potato digging, FYM should be applied. After that a pre-irrigation should be given after ensuring levelling by cross tilling with tine cultivator followed by planking. When the field comes in condition, field should be cross-harrowed once followed by one cross-tilling with tine cultivator and planking. For sowing, ridges are to be made in the field at 60 cm apart with the help of ridger.

Cultural practices

Seed rate (kg/ha)	18		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Solar seed treatment	For 2 hrs.	For 2 hrs. during mid-day after pre-soaking in water for 2 hrs.
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma harzianum	4 g/kg seed	Seed treatment

Spacing (row x plant) in cm	45 x 30		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	12 tonnes	
	Rhizobium	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	4.83 tonnes	30 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	9	Pod formation	5
Major weeds	**Local name**	**English name**	**Scientific name**
	Grasses		
	Makra ghas	Crow foot grass	*Dactyloctenium aegyptium*
	Doobghas	Barmuda grass	*Cynodon dactylon*
	Broad leaf weeds		
	Pattharchatta	Horse purslane	*Trianthima portulacastrum*
	Makoi	Black nightshade	*Solanum nigrum*
	Sedges		
	Motha	Nut Grass	*Cyprus rotundus*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 DAS	Hand weeding	
	40 DAS	Hand weeding	
	60 DAS	Hand weeding	

Organic plant protection practices	Name of pest/ disease	Organic material recommended for control	Quantity
	Diseases		
	Cercospora leaf spot	• Grow resistant varieties • Crop rotation • Collection and destruction of infected crop debris	
	Fusarial wilt	• Long crop rotation • Deep summer ploughing • Soil solarisation • Soil application of *Pseudomonas fluorescence* & *Trichoderma harzianum*	5kg/ha in 100kg precolonized well decomposed FYM
	Powdery mildew	• Good nutrition to plants • Apply sprinkler irrigation to crop • Foliar spraying of neem oil or neem-seed-kernel-extract	At 3% or 5% concentration, respectively
	Yellow vein mosaic	• Grow resistant varieties • Grow okra in wide spaced rows or as border/intercrop • Rouging and destruction of infected plants • Control of whitefly vectors through foliar spraying of neem oil or neem-seed-kernel-extract	At 3% or 5% concentration, respectively If, whitefly population observed
	Root knot nematode	• Soil solarisation • Crop rotation with non-host crop	5kg/ha in 100kg precolonized well decomposed FYM

	• Soil application of *Trichoderma harzianum*	
Insect-pests		
Jassids	• Grow okra in wide spaced rows or as border/intercrop • Foliar spraying of neem oil or neem-seed- kernel-extract	At 3% or 5% concentration, respectively if jassid populations observed
Fruit borer	Foliar spraying of neem oil or neem-seed- kernel-extract	At 3% or 5% concentration, respectively
Red spider mite	• Give sprinkler irrigation • Foliar spraying of neem oil or neem-seed- kernel-extract	At 3% or 5% concentration, respectively

Yield

Year	1st	2nd	3rd	4th	Mean
Economic yield (kg/ha)	4551	1558	10280	10530	6730

Okra var. Arka Anamika

Potato under organic condition

Maize (green cobs)

Particulars	***Kharif***
Crop	Maize (green cobs)
Sowing/planting	First fortnight of July
Harvesting	First fortnight of October
Variety	*Madhuri*

Important features of suitable variety

Variety	***Madhuri***
Duration (days)	
Average yield under organic condition (kg/ha)	10000
Source (s) of availability	ANGRAU, Hyderabad
Suitable regions/districts in the state	Andhra Pradesh and other maize growing regions

Field preparation: The first soil opening should be done by 2-3 cross harrowing for the proper incorporation of okra debris in to soil. Then the field should be irrigated for proper decomposition of okra debris and ensuring proper moisture for maize germination. When the field comes in condition, 2 cross harrowing followed by two cross tilling with cultivators or should be done. After that 1-2 planking should be done to ensure proper levelling. For sowing maize broad beds of 60 cm width should be made with the help of soil shaper.

Cultural practices

Seed rate (kg/ha)	20		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate (kg/ha or lit/ha)**	**Method of application**
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma harzianum	4 g/kg seed	

Spacing (row x plant) in cm	60 x 20		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	10 tonnes	
	Azotobactor	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic manures	Source	Quantity/ha	Stage of crop
	Vermicompost	4.0 tonnes	30 DAS
	Panchagavya	15 litres	Spray twice at 45 and 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3	Silking, tasseling	5
Major weeds	**Local name**	**English name**	**Scientific name**
	Grasses		
	Makra ghas	Crow foot grass	*Dactyloctenium aegyptium*
	Sewai/Sawa	Barnyard grass	*Echinochloa colonum*
	Samak/Sawa	Common barnyard grass	*Echinochloa crusgali*
	Takri	Crabgrass	*Digitaria ciliaris*
	Doobghas	Barmuda grass	*Cynodon dactylon*
	Banchari	Johnson grass	*Sorghum helepanse*
	Broad leaf weeds		
	Baridhudi	Hairy spurge	*Euphorbia hirta*
	Chouli	Pig weed	*Amaranthus viridis*

	Pattharchatta	Horse purslane	*Trianthima portulacastrum*
	Lalmurga	Cockscomb,	*Celosia argentia*
	Kankoua	Dayflower	*Commelina benghalensis*
	Hulhul/Chilmil	Hurricane weed	*Phylanthus niruri*
	Makoi	Black nightshade	*Solanum nigrum*
	Lunia	Purslane	*Portulaca oleraceae*
	Sedges		
	Motha	Purple nutsedge	*Cyprus rotundus*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30 DAS	Hand weeding	
	50 DAS	Hand weeding	
		Stale seed bed	
Organic plant protection practices	**Name of pest / disease**	**Organic material recommended for control**	**Quantity**
	Diseases		
	Soil borne diseases	Seed & seedling treatment with *Pseudomonas fluorescence* & *Trichoderma harzianum*	*Pseudomonas* @ 10 g/kg seed &*Trichoderma* @ 4 g/kg seed
	Leaf spot/blight	• Crop rotation • Deep summer ploughing • Clean cultivation	
	Rust	Foliar spraying of sour butter milk	5 L diluted in 200L water (1000 L solution for 1ha)

	Banded leaf and sheath blight	Foliar spraying of *Pseudomonas fluorescence* and/ or *Trichoderma harzianum*	Two sprays at 10 days interval after appearance of symptoms @5g/L water
	Insect-Pests		
	1. Maize Stem borer	Release of *Tricogramma chilonis* (Tricho-cards)	Tricho-cards @ 1 lakh parasitized eggs/ha at 10 days intervals 5-6 times

Yield

Year	1st	2nd	3rd	Mean
Economic yield (kg/ha)	9160	9060	8860	9027

Maize cob under organic production system

Maize+cowpea under organic system

Mustard + radish (1:2)

Particulars	Details
Crop (s)	Mustard + Radish
Sowing time	Second fortnight of October
Harvesting time	First fortnight of March
Varieties	Mustard (Pusa Bold,RH- 406, RGN- 229), Radish (Ivory white)

Important features of suitable varieties

Varieties	Mustard			Radish
	Pusa Bold	**RH- 406**	**RGN- 229**	**Ivory white**
Duration (days)	140	145-150	46	40-50
Average yield under organic condition (kg/ha)	1000	2000	1950	14410
Source (s) of availability			SKRAU, Bikaner	
Suitable regions/districts in the state	All India	Delhi, Haryana, J & K, Punjab and parts of Rajasthan	Delhi, Haryana, J & K, Punjab and parts of Rajasthan	
Specific tolerance to drought / waterlogging		Lodging resistant	Tolerant to lodging, shattering, high temperature & salinity	

Field preparation: To ensure a clean and well pulverised seedbed for mustard, the land should be well prepared first by ploughing deep with soil turning plough, followed by two cross harrowing. Each harrowing should be followed by planking for ensuring proper levelling. After field preparation, ridges are made in the field at 60 cm apart with the help of ridger. While sowing the mustard seed should be shown on the top and the radish can be sown on both the sides of rides.

Cultural practices

Seed rate (kg/ha)	Mustard- 4 kg, Radish- 10 kg		
Pre-sowing/planting treatment	**Material of seed/seedlings**	**Recommended rate**	**Method of application**
	Pseudomonas fluorescence	10 g/kg seed	Seed treatment
	Trichoderma harzianum	4 g/kg seed	Seed treatment
Spacing (row x plant) in cm	45 x 10		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	12 tonnes	
	Azotobactor	10 kg	
	PSB	10 kg	
	Trichoderma	5 kg	
	Neem cake	200 kg	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Stage of crop**
	Vermicompost	4.83 tonnes	30 DAS
	Panchagavya	15 litres	Spray twice at 45 and 60 DAS
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	5	Pre-flowering and pod filling	5
Major weeds	**Local name**	**English name**	**Scientific name**
	Grasses		
	Jangali Jai	Wild oat	*Avena fatua*
	Daub ghas	Bermuda grass	*Cynodon dactylon*
	Baluri		*Phalaris minor*
	-	Bluegrass	*Poa annua*

	Broad leaf weeds		
	Chatrimatri	Chickling vetch	*Lathyrus sativus*
	Lunia	Common purslane	*Portulaca oleracea*
	Keteli	Creeping thistle	*Circium arvense*
	Bathua	Lamb’s-quarters	*Chenopodium album*
	Hirankhuri	Field bindweed	*Convolvulus arvensis*
	Peeli Senji	Yellow sweet clover	*Melilotus indica*
	Gajri	Fineleaf fumitory	*Fumaria parviflora*
	Sedges		
	Motha	Yellow nutsedge	*Cyperus rotundus*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30 DAS	Thinning and hand/mechanical weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Diseases		
	Soil borne diseases	Neem cake	Soil application of 200 kg/ha
		P. fluorescence and *T. harzianum*	Seed treatment with @ 5 g/kg seed
	Alternaria leaf spot / blight, White rust, Downey mildew	Early sowing	By first fortnight of October
	Insect-pests		
	Mustard saw fly	Foliar spraying of neem oil or neem-seed- kernel-extract	At 3% or 5% concentration, respectively

	Foliar application of *Beauveria bassiana*	At two leaf stage
Mustard aphid	Early sowing	By first fortnight of October
	Foliar spraying of neem oil or neem-seed- kernel-extract	At 3% or 5% concentration, respectively just after appearance of aphid populations

Yield

Year	**1st**	**2nd**	**3rd**	**Mean**
Economic yield (kg/ha) (Mustard + Radish)	145+9580	6940+14200	6420+14620	4502+12800

Mustard under organic condition

Pusa bold mustard under organic condition

UTTARAKHAND

Suggested cropping systems (based on testing under NPOF)

1. Basmati rice-wheat-*sesbania*
2. Basmati rice-lentil-*sesbania*
3. Basmati rice-vegetable pea-*sesbania*
4. Basmati rice-*brassica napus*-*sesbania*
5. Basmati rice-chickpea-*sesbania* (Under biodynamic practices)

Details of crops in cropping systems

Basmati rice

Particulars	***Kharif***
Crop	Basmati rice
Sowing/planting	Ist fortnight of June (sowing) IInd fortnight of June (Transplanting)
Harvesting	IInd fortnight of October (Harvesting)
Variety	Pusa Basmati-1

Important features of suitable variety

Variety	**Pusa Basmati-1**
Duration (days)	Medium (130-135days)
Average yield under organic condition (kg/ha)	3500 kg/ha
Source (s) of availability	In-situ organic field
Suitable regions/districts in the state	Udham Singh Nagar
Specific resistance / tolerance to disease	Blast

Nursery raising practices

Area of nursery required for 1 ha	1000 m^2		
Nursery raising method	Wet nursery		
Bed size (length X breadth in m)	5m x 2m		
Seed sowing rate/m^2	30 g		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^{2}area**	**Method of application**
	Common salt	1.65 kg salt/10 l of fresh water	Dipping the seeds
	Pant Bioagent-3 (mixture of *Pseudomonas* &*Trichoderma)*	10g/kg seed	Seed treatment
Source and optimum quantity of organic manures	**Materials**	**Quantity/ m^{2}area**	**Method of application**
	Sesbania green manuring	1.0-1.5 kg	Incorporation in soil
	FYM	2.5 kg/m^2	broadcast
	Leacheate of vermicompost + $ZnSO_4$	10% + 0.5 %	sprays at 10 & 20 days after sowing
Irrigation practices	3 irrigations		
Weed management	1 HW at 15 DAS		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	**Quantity/ m^{2}area**
	Stem borer	Cow urine (10 %) + Neem leaves (10 %) or neem oil (1-2%)	
	-	Precautionary spray of *Trichoderma* + *Pseudomonas* (each @ 5g/l) after 15 days or Pant Bioagent-3 @ 10 g/l of water	
Optimum age of nursery (days)	20-25 days		

Field preparation: For transplanted rice, in-situ *Sesbania* green manure grown and incorporated with the help of mould board plough followed by two round of puddling by puddler.Soil application of PSF &*Trichoderma* each @ 5g/l or Pant Bioagent-3 @ 10 g/l of water (5.0 kg Pant Bio-agent-3 with 500 l water/ha) after incorporation of green manure at the time of soil preparation.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pant Bioagent-3 (*Pseudomonas*+ *Trichoderma)*	250 g/l water	Seedling treatment through root dipping
Spacing (row x plant) in cm	20 x10cm		
Number of seedlings/hill	2		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Green manure	15-20 t/ha green biomass	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	V.C. (if FYM has not been applied)	2.5 tonnes	20 DAT
	Cow urine fortified with Neem leaves (one kg green leaves/ 10 litre of urine)	50 litres (10% with 500 litres water)	3-4 sprays at 15 days interval start from 20-25 days after transplanting
	Or Cow urine + neem oil	10% + 1%	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	6-8	Transplanting, tillering, PI, flowering & grain filling	5.0-7.0 cm
Major weeds	**Scientific Name**	**English Name**	**Local Name**
	Echinochloa colonum	Wild rice	Chotta sawan
	Echinochloa crusgalli	Banyard grass	Sawan

	Leptochloa chinensis		*American ghas*
	Cyperus rotundus	Purple nut sedge	Motha
	Cyperus iria	Yellow sedge	Motha
	Cyperus difformis	Common sedge	Motha
	Ec*lipta alba*	false daisy	Jal bhangra
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 & 40 DAT	One mechanical weeding by conoweeder at 15 DAT followed by one or two hand weeding 25 & 45 DAT	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Yellow stem borer, Leaf folder, Brown plant hopper	Pheromone traps Cow urine fortified with Neem leaves (one kg green leaves/ 10.0 l of urine) or Cow urine + neem oil (10 % +1%)	20 traps/ha 50 l/ha (10 % with 500 litre water / ha).50 litre cow urine + 5 litre neem oil/ha.
	Bacterial leaf blight Sheath blight Sheath rot Brown leaf spot	Cow urine fortified with Neem leaves (one kg green leaves/ 10.0 l of urine) + *Trichoderma* + *Pseudomonas* (each @ 5g/l) or Pant Bioagent-3 @ 10 g/l of water	50 litre cow urine+ 5 kg Pant Bio-agent 3 in 500 litre of water /ha

Yield

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean
Economic yield (kg/ha)	2266	2344	2456	2963	3445	2885	3113	3715	3925	3012

Wheat

Important features of suitable variety

Variety	PBW-343
Duration (days)	Medium (135-150days)
Average yield under organic condition (kg/ha)	2911 kg/ha
Source (s) of availability	In-situ
Suitable regions/districts in the state	Indo Gangetic Plain (U.S.Nagar)
Specific resistance / tolerance to disease	Resistant to brown and yellow rust, tolerant to Karnal Bunt

Field preparation: After harvest of rice, one ploughing followed by two harrowing was done.

Cultural practices

Seed rate (kg/ha) (Not applicable for nursery crops)	100 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pant Bioagent-3 (mixture of *Pseudomonas* + *Trichoderma*)	10g/kg seed	Seed treatment
Spacing (row x plant) in cm	22 cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	10 tonnes	
	Vermicompost	5 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine fortified with Neem leaves (one kg green leaves/ 10 litre of urine)	50 litres (10% with 500 litres water)	Two sprays at 30 and 60 days after sowing

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	3-4	Crown root initiation, tillering, flowering and grain-filling stage	5-6 cm
Major weeds	**Scientific Name**	**English Name**	**Local Name**
	Phalaris minor *Chenopodium album* *Lathyirus aphaca* *Melilotus alba* *Melilotusindica* *Fumaria perviflora* *Anagallis arvensis*	Bird's seed grass Goose foot *Crow pea* *White sweet clover* *Yellowsweetclover* *Fumitory* *Blue pimpernel*	Gehun ka mama Bathua *Chatri-matri* *Sufaid Senji* *Zard Senji* *Jungli gazar* *Krishna -neel*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	30 & 45 DAS	Stale bed + one hand weeding or two hand weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Wheat aphid	Cow urine fortified with Neem leaves (one kg green leaves/ 10.0 litre of urine) or Cow urine + neem oil (10% +1%)	50 l/ha (10 % with 500 litre water /ha) or 50 litre cow urine + 5 litre neem oil/ha
	Brown rust, Yellow rust, Powdery mildew	Cow urine + Pant Bioagent-3 (mixture of *Pseudomonas* + *Trichoderma*)	10% cow urine + 10 g/l of water (50 litre cow urine + 5 kg Pant Bio-agent 3 in 500 litre water/ha)

Yield

Year	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**Mean**
Economic yield (kg/ha)	1383	1735	2662	2359	2493	3645	3677	4103	4142	2911

Sesbania

Important features of suitable variety

Variety	**(Pant Ses-1)**
Duration (days)	50-55 days
Average yield under organic condition (kg/ha)	16000 kg/ha(green biomass); 3450 kg/ha (dry matter)
Source (s) of availability	Seed Production Centre, Pantnagar
Suitable regions/districts in the state	Udham Singh Nagar

Field preparation: After harvest of *Rabi* crops, field was harrowed and seeds of *Sesbania* were sown @ 30 kg/ha. It should be ensured that moisture availability should be there otherwise, irrigation should be given immediate after sowing of *Sesbania* seed.

Basmati rice

Particulars	***Kharif***	***Rabi***	**Summer**
Crop	Basmati rice	Lentil	*Sesbania*
Sowing/planting	Ist fortnight (FN) of June (sowing) IInd fortnight of June (Transplanting)	IInd FN of November (sowing)	Ist FN of May
Harvesting	IInd fortnight of October (Harvesting)	Ist FN of April (Harvesting)	IInd FN of June (Harvesting)
Varieties	Pusa basmati-1	Pant Lentil-6	Pant Ses-1

Lentil

Important features of suitable variety

Variety	**Pant Lentil-6**
Duration (days)	Medium (120-135)
Average yield under organic condition (kg/ha)	851 kg/ha
Source (s) of availability	In-situ
Suitable regions/districts in the state	U.S.Nagar
Specific resistance / tolerance to pest	Tolerant to pod borer
Specific resistance / tolerance to disease	Resistant to rust, wilt and Aschochyta blight

Field preparation: After harvest of rice, one ploughing followed by two harrowing was done.

Cultural practices

Seed rate (kg/ha)	30 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pant Bioagent-3 (mixture of *Pseudomonas* + *Trichoderma*)	10g/kg seed	Seed treatment
Spacing (row x plant) in cm	30 x 10cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	5 tonnes	
	Vermicompost	2.5 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine fortified with Neem leaves (one kg green leaves/ 10 l of urine)	50 litres (10% with 500 litres water)	Two sprays at 30 and 60 days after sowing
Major weeds	**Scientific Name**	**English Name**	**Local**
	Phalaris minor	Bird's seed grass	Gehun ka mama
	Chenopodium album	Goose foot	Bathua
	Lathyirus aphacamatri	Crow pea	*Chatri-Sufaid*
	Melilotus alba Senji	*White sweet clover*	*Jungli Senji*
	Melilotus indica	*Yellow sweet clover*	*Zard*
	Fumaria pervifloragazar	*Fumitory*	*Papara*
	Anagallis arvensis	*Blue pimpernel*	*Krishna neel*

Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 & 45 DAS	Stale bed + hand weeding or one mechanical + one hand weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Wilt Rust	Cow urine + Pant Bioagent-3 (mixture of *Pseudomonas* + *Trichoderma*)	10% cow urine + 10 g/l of water (50 litre cow urine + 5 kg Pant Bio-agent 3 in 500 litre water/ ha); 5-6 sprays are required in 15 days intervals

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Economic yield (kg/ha)	354	445	774	731	972	601	1234	1702	852

Incorporation of *Sesbania* Green manure

Sesbania green manure (var. Pant Ses-1)

Vegetable pea

Important features of suitable variety

Variety	**Arkel**
Duration (days)	Early (90-120d)
Average yield under organic condition (kg/ha)	4124 kg/ha
Source (s) of availability	In-situ
Suitable regions/districts in the state	U.S.Nagar
Specific resistance / tolerance to disease	Susceptible to powdery mildew

Field preparation: After harvest of rice, one ploughing followed by two harrowing were done.

Cultural practices

Seed rate (kg/ha)	80		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pant Bioagent-3 (Pseudomonas + Trichoderma)	10g/kg seed	Seed treatment
Spacing (row x plant) in cm	30 x 10cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	5.0 tonnes	
	Vermicompost	2.5 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Cow urine fortified with Neem leaves (one kg green leaves/ 10 l of urine)	50 litres (10 % with 500 litres water)	One spray after 60 days of sowing

Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	1	Pre-flowering	2-3 cm
Major weeds	**Scientific Name**	**English Name**	**Local Name**
	Phalaris minor	Bird's seed grass	Gehun ka mama
	Chenopodium album	Goose foot	Bathua
	Chenopodium murale	*Fat hen*	*Karund*
	Melilotus alba	*White sweet clover*	*Sufaid Senji*
	Melilotusindica	*Yellow sweet clover*	*Zard Senji*
	Fumaria perviflora	*Fumitory*	*Jungli gazar*
	Cynodon dactylon		*doob-ghas*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	25 & 45 DAS	Stale bed preparation + 1 Hand weeding or one mechanical + 1 HW at 25 & 45 DAS	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Rust, Powdery Mildew, Blight	*Pseudomonas florescence & Trichoderma spp.*	Each @ 5g/L at the time of soil preparation, before and after flowering to control disease.
	Pea leaf minor, Pod borer	Cow urine fortified with Neem leaves (one kg green leaves/ 10.0 l of urine) or Cow urine + neem oil (10 % +1%)	50 l/ha (10 % with 500 litre water / ha).50 litre cow urine + 5 litre neem oil/ha.

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha)	3408	3198	2573	2479	3393	3941	5534	6272	6320	4124

Treatment of lentil with Pant Bioagent-3 (mixture of *Pseudomonas* + *Trichoderma*)

Vegetable pea under organic mode

Brassica napus

Important features of suitable variety

Variety	**GLS-1**
Duration (days)	Medium (135-150days)
Average yield under organic condition (kg/ha)	956 kg/ha
Source (s) of availability	In-situ
Suitable regions/districts in the state	U.S.Nagar

Field preparation: After harvest of rice, **o**ne ploughing followed by two harrowing were done.

Cultural practices

Seed rate (kg/ha)	2-3 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pant Bioagent-3 (Pseudomonas + Trichoderma)	10g/kg seed	Seed treatment
Spacing (row x plant) in cm	30X20		
Basal application of organic manures	**Source**	**Quantity/ha**	
	FYM	10.0 t/ha	
	Vermicompost	5.0 t/ha	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	V.C.	5 tonnes	20 DAS
	FYM	10 tonnes	Basal
	Cow urine fortified with Neem leaves (one kg green leaves/ 10 l of urine)	50 litres (10 % with 500 litres water)	One sprays after 60 days of sowing

	Or Cow urine+ neem oil	10% + 1%	
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	1	Critical irrigation stage pre-flowering	2-3 cm
Major weeds	**Scientific Name**	**English Name**	**Local Name**
	Phalaris minor *Chenopodium album* *Lathyirus aphaca* *Convolvulus arvensis* *Melilotus alba* *Melilotus indica* *Fumaria perviflora* *Anagallis arvensis* *Cynodon dactylon*	Bird's seed grass Goose foot Crow pea Field binweedkhuri White sweet clover Yellow sweeclover Fumitory Blue pimpernel	Gehun ka mama Bathua Chatri-matri Hiran Sufaid Senji Zard Senji Jungli gazar Krishna – neeldoob-ghas
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 & 40 DAS	Stale bed + 1Hand weeding or one mechanical weeding + 1 HW	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Root rot, White rust, Downey mildew	*Pseudomonas florescence & Trichoderma spp.*	each @ 5g/L at the time of soil preparation, before and after flowering to control disease.
	Mustard Aphid, Mustard Saw fly	Cow urine fortified with Neem leaves (one kg green leaves/ 10.0 l of urine) or Cow urine + neem oil (10 % +1%)	50 l/ha (10 % with 500 litre water / ha).50 litre cow urine + 5 litre neem oil/ha.

Yield

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Economic yield (kg/ha)	342	300	603	785	840	915	1158	1777	1886	956

Basmati rice

Variety	***Kharif***
Crop	Basmati rice-chickpea under biodynamic practices
Sowing/planting	Ist fortnight of June (sowing) IInd fortnight of June (Transplanting)
Harvesting	IInd fortnight of October (Harvesting)
Variety	Pusa -1121

Important features of suitable variety

Variety	**Pusa 1121**
Duration (days)	Medium (135-140 days)
Average yield under organic condition (kg/ha)	3958 kg/ha
Source (s) of availability	In-situ organic field
Suitable regions/districts in the state	Udham Singh Nagar

Nursery raising practices

Area of nursery required for 1 ha	1000 m^2		
Nursery raising method	Wet nursery		
Bed size (length x breadth in m)	5m x 2m		
Seed sowing rate/m^2	30 g		
Pre-sowing seed/soil treatment	**Materials**	**Quantity/kg of seed or per m^2area**	**Method of application**
	Common salt	1.65 kg salt/10 l of fresh water	Dipping the seeds
	Pant Bioagent-3 (mixture of *Pseudomonas* & *Trichoderma)*	10g/kg seed	Seed treatment
Source and optimum quantity of organic manures/other nutrient source/m^2 of nursery	**Materials**	**Quantity/ m^2area**	**Method of application**
	Sesbania green manuring	1.0-1.5 kg	Incorporation in soil
	FYM	2.5 kg/m^2	broadcast

	Leachates of vermicompost + $ZnSO_4$	10% + 0.5 %	sprays at 10 & 20 days after sowing
Irrigation practices	3 irrigations		
Weed management	1 HW at 15 DAS		
Organic plant protection practices	**Name of pest/ disease**	**Recommended organic material used for control**	
		Leacheate of Vermicompost + Cow urine (10 %) + Neem leaves (10 %) or neem oil (1-2%)	
		Trichoderma + *Pseudomonas* (each @ 5g/l) after 15 days or Pant Bioagent-3 @ 10 g/l of water	
Optimum age of nursery (days)	20-25 days		

Field preparation: For transplanted rice, in-situ *Sesbania* green manure grown and incorporated with the help of mould board plough followed by two round of puddling by puddler. Soil application of PSF & *Trichoderma* each @ 5g/l or Pant Bioagent-3 @ 10 g/l of water (5.0 kg Pant Bio-agent-3 with 500 l water/ha) was done after incorporation of green manure at the time of soil preparation.

Cultural practices

Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pant Bioagent-3 (*Pseudomonas*+ *Trichoderma)*	250 g/l water	Seedling treatment through root dipping
Spacing (row x plant) in cm	20 x 10cm		
Number of seedlings/hill (in nursery crops only)	2		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Green manure	16-20 tonnes	
	Soil application of BD-500, FYM, E.C.	62.5 g/ha, 5 t/ha, 5 t/ha (If green crop was not taken)	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	Vermicompost	2.5 tonnes	20 DAT
	Neem cake	0.5 tonnes	20 DAT

	BD-501	2.5 g	Flowering & seed-setting stage(as per biodynamic calendar)
	CPP	2.5 kg	Flowering & seed-setting stage
	Panchgavya	@0.3% (1.5 l Panchgavya in 500 l of water)	Flowering & 15 days after flowering
	Cow urine fortified with Neem leaves (one kg green leaves/ 10 l of urine)	50 l/ha (10 % with 500 litre water /ha)	3-4 sprays at 15 days interval start from 20-25 days after transplanting
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	**Depth of irrigation (cm)**
	6-8	Transplanting, tillering, PI, flowering & grain filling	5.0-7.0 cm
Major weeds	**Scientific Name**	**English Name**	**Local Name**
	Echinochloa colonum	Wild rice	Chotta sawan
	Echinochloa crusgalli	Banyard grass	Sawan
	Leptochloa chinensis	Purple nut sedge	Motha
	American ghas	Yellow sedge	Motha
	Cyperus rotundus		
	Cyperus iria		
	Cyperus difformis	Common sedge	Motha
	Eclipta alba	false daisy	Jal bhangra
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 & 40 DAT	One mechanical weeding by conoweeder 15 DAT followed by one or two hand weeding 25 & 45 DAT	

Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity**
	Yellow stem borer	Pheromone traps	20 traps/ha
	Leaf folder Brown plant hopper	Cow urine fortified with Neem leaves (one kg green leaves/ 10.0 l of urine) or Cow urine + neem oil (10 % +1%)	50 l/ha (10 % with 500 litre water / ha).50 litre cow urine + 5 litre neem oil/ha.
	Bacterial leaf blight Sheath blight Sheath rot Brown leaf spot	Cow urine fortified with Neem leaves (one kg green leaves/ 10.0 l of urine) + *Trichoderma* + *Pseudomonas* (each @ 5g/l) or Pant Bioagent-3 @ 10 g/l of water	50 litre cow urine+ 5kg Pant Bio-agent 3 in 500 litre of water /ha

Yield

Year	2009	2010	2011	2012	Mean
Economic yield (kg/ha)	3598	3144	4555	4535	3958

Chickpea

Important features of suitable variety

Variety	**Pant Kabuli Chana-1**
Duration (days)	Medium (120-135)
Average yield under organic condition (kg/ha)	1809 kg/ha
Source (s) of availability	In-situ
Suitable regions/districts in the state	U.S.Nagar
Specific resistance / tolerance to disease	Resistant to botrytis grey mould

Field preparation: After harvest of rice, one ploughing followed by two harrowing was done.

Cultural practices

Seed rate (kg/ha)	30 kg/ha		
Pre-sowing/planting treatment of seed/seedlings	**Material**	**Recommended rate**	**Method of application**
	Pant Bioagent-3 (mixture of *Pseudomonas* + *Trichoderma*)	10g/kg seed	Seed treatment
Spacing (row x plant) in cm	30 x 10cm		
Basal application of organic manures	**Source**	**Quantity/ha**	
	Soil application of BD-500	62.5 g	
	FYM	2.0 tonnes	
	Edible cake	2.0 tonnes	
	Vermicompost	1.0 tonnes	
	Neem cake	0.2 tonnes	
Top dressing of organic manures	**Source**	**Quantity/ha**	**Days after sowing/ planting or stage of crop**
	BD-501	2.5 g	Flowering & fruit-setting stage(as per biodynamic calendar)

	CPP	2.5 kg	Flowering & fruit-setting stage
	Panchgavya	@0.3% (1.5 l Panchgavya in 500 l of water)	Flowering & 15 days after flowering
	Cow urine fortified with Neem leaves (one kg green leaves/ 10 l of urine)	50 l/ha (10 % with 500 litre water /ha)	Two sprays at 30 and 60 days after sowing
Irrigation practices	**Number of irrigations**	**Most critical stages for irrigation**	
	1	Flowering or pod formation	
Major weeds	**Scientific Name**	**English Name**	**Local Name**
	Phalaris minor	Bird's seed grass	Gehun ka mama
	Chenopodium album	Goose foot	Bathua
	Chenopodium murale	*Fat hen*	*Karund*
	Melilotus alba	*White sweet clover*	*Sufaid Senji*
	Melilotusindica	*Yellow sweet clover*	*Zard Senji*
	Fumaria perviflora	*Fumitory*	*Jungli gazar*
	Vicia sativa	*Common vetch*	*Choti phalli/ Akra*
	Anagallis arvensis	*Blue pimpernel*	*Krishna-neel*
Weed management	**Critical stage of weeding**	**Recommended practice for organic condition**	
	20 & 40 DAS	Stale bed + hand weeding	
Organic plant protection practices	**Name of pest/ disease**	**Organic material recommended for control**	**Quantity (kg or litres/ ha)**
	Wilt, Blight	Cow urine + Pant Bioagent-3 (mixture of *Pseudomonas* + *Trichoderma*)	10% cow urine + 10 g/l of water (50 litre cow urine + 5 kg Pant Bio-agent 3 in 500 litre water/ ha); 5-6 sprays are required in 15 days intervals

	Pod borer	Cow urine fortified with Neem leaves (one kg green leaves/ 10 l of urine)	
		HNPV	1.5 l/ha

Yield

Year	2009-10	2010-11	2011-12	2012-13*	Mean
Economic yield (kg/ha)	1458	1335	2003	2440	1809

Details of Specific Practices/products used/recommended

Neem fortified cow urine: Cow urine can be fortified with neem leaves @ 1kg fresh neem leaves in 10 l of cow urine kept for 10 to 15 days. Alternately, 1% neem oil can also be used for the fortification of cow urine at the time of spraying.

***Panchgavya*:** Panchgavya is basically the mixture of five main ingredients *viz.,* cow dung, cow ghee, cow urine, cow milk and cow curd. In addition to above five ingredients, tender coconut water, jaggery and well ripened banana can also be used for its preparation. For preparation of panchgavya, mix cow dung (7kg) and cow ghee (1kg) in a wide- mouthed plastic can and should be mixed in morning and evening hours and kept for 3 days. After 3 days, mix cow urine (10 l) and water (10 l) and keep it for 15 days with regular mixing both in morning and evening hours. After 15 days, mix cow milk (3 l), cow curd (2 l), tender coconut water (3 l), Jaggery (3 kg) and well ripened banana (12 nos.) and container should be kept open under shade and stock Panchgavya solution will be ready after 30 days.

BD-500 (Cow horn Manure): It is basically fermented cow dung which is buried in September-November and lifted in February-March. For the preparation of BD-500, cow horns and fresh cow dung from a lactating cow is needed (average 50-150g dung/horn). For this burial pits were prepared (18 inches deep) and the pit area should not be subject to flooding, vigorous root systems or earthworms. Filled cow horns with cow dung in October-November were placed in burial pits, 1 inches apart with base downwards, surrounded with 50% compost and soil and bury for 4 to 6 months keeping the burial pit soil moist and shaded at temperature approximately 20^0C and free from weeds and earthworms. After 4 months, check for dung fermentation (if green cow dung has turned into dark, smooth earthy smelling humus) and lifted.

BD-501(Cow horn Silica): It is finely ground quartz crystals especially prepared. The crystals used should be of good quality, shape and clear. It is buried in the similar manner to preparation of BD-500 but this time buried during the summer time (April-May and lifted in September). For the preparation of BD-501, cow horns and silica quartz crystals are needed (average 200-300g powdered quartz crystals/horn). Silica quartz is crushed and grinded to make a fine powder between two plate glasses and moisten with water to make a stiff paste to fill the horns and buried in soil pit, 1 inch apart with base downwards surrounded with 50% compost and soil.

Cow Pat Pit (CPP): It is cow manure mixed with crushed egg shell and basalt dust, which is put into 12 inches deep pit lined with bricks. The dung is fermented, together with preparation 502-507 for a period of 3 to 4 months. When mature, it is mixed with water, @ 1 kg in 40 litres of water per acre (1 CPP pit is sufficient to cover 40 acres) and 60 kg of cow dung gives about 30-35 kg of CPP after fermentation. CPP is applied in the evening during the cooler months.

CHAPTER 6

Niche Areas and Crops for Promotion of Organic Farming

Organic farming should be promoted in phased manner by identifying niche areas and crops. “Certified organic farming” with combination of tradition, innovation and scientific organic packages should be promoted in the de-facto organic areas (hills) and rainfed/ dryland regions for safe food security and climate resilience, besides increased income of farm households.

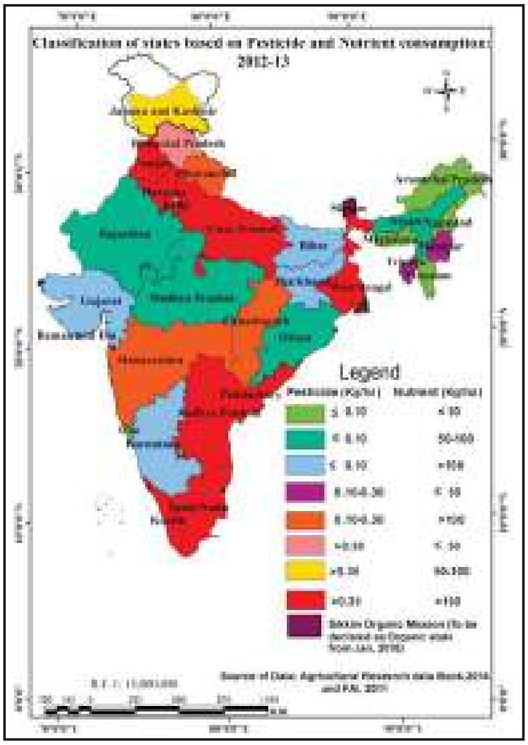
Arunachal Pradesh, Nagaland, Meghalaya, Mizorum, Assam, Rajasthan, Madhya Pradesh, Odisha, Bihar, Jharkhand, Gujarat, Karnataka, Himachal Pradesh, Jammu & Kashmir and Uttarakhand are very much suitable for promotion of organic farming based on its usage of inputs. Further, towards organic approach having non-pesticide but with chemical fertilizers can be promoted in Tamil Nadu, Kerala, Andhra Pradesh, West Bengal, Uttar Pradesh, Punjab and Haryana states. This approach will help to improve the food security of country. There is a great potential for organic farming to flourish in this country and given an appropriate institutional and policy framework, it will not be very difficult to promote the existing ‘de-facto organic’ farms in N E region and Western India to the category of certified organic farms. This would enable the small farmers to take advantage of the lucrative mar-ket for certified organic products in the developed world, which could directly contribute towards the improvement of their economic well-being. In India, some regions like as N E Region, Western Rajasthan Himalayan region and chota Nagpur plateau are naturally growing crops without fertilizer and pesticides. Government should concentrate these areas and try to give them organic certificate. Statewise consumption of fertilizers in NEH indicates all the states are having much lesser consumption of nutrients through chemical fertilizers.

Niche areas for organic farming

First tier states UT’s: Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Daman & Diu, Goa, Lakshadweep, Meghalaya, Mizorum, Nagaland, Sikkim, Tripura

Second tier states UT’s: Bihar, Chhatisgarh, Dadra and Nagar Haveli, Delhi, Gujarat, Himachal Pradesh, Jammu, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Odisha, Puducherry, Rajasthan, Uttarakhand

Towards organic approach states/UT's (Non-pesticide but with chemical fertilizers promotion) : Andhra Pradesh, Chandigarh, Haryana, Maharashtra, Punjab, Tamil Nadu, Telangana, Uttar Pradesh, West Bengal



Niche crops for promotion of organic farming

Area	Crops
Rainfed regions of Madhya Pradesh, Karnataka	Soybean, finger millet, durum wheat
Hilly regions of Himachal Pradesh, Uttrakhand, J&K including NEH region	Turmeric, ginger, cauliflower, cabbage, garlic, pea, capsicum, tomato, rice, potato
Tribal areas of Jharkhand, Chhattisgarh	Rice, durum wheat, mustard, lentil, soybean, chickpea
Irrigated region of Punjab, Haryana, Uttar Pradesh	Basmati rice, maize, turmeric, onion, garlic, greengram
Kerala	Black pepper, ginger, turmeric
Rajasthan and Gujarat	Coriander, fennel
Rainfed region of Gujarat, Maharashtra, MP, Tamil Nadu	Cotton

CHAPTER 7

Minutes of Workshop on Organic Farming: Concerns About Crop Productivity and Soil Health

7 January 2016

Workshop on ***Organic Farming: Concerns about crop productivity and soil health*** sponsored by Department of Agriculture, Cooperation and Farmers Welfare (DAC&FW) under the Ministry of Agriculture and Farmers Welfare was organized by ICAR-Indian Institute of Farming Systems Research, Modipuram on 7 January 2016. Members of Task Force on Organic Farming and Non-chemical farming, Principal Investigators of Network Project on Organic Farming (NPOF), officials from DAC&FW, National Centre of Organic Farming and Scientists of ICAR-IIFSR participated in the workshop and deliberated on policy for promotion for organic farming in the country without compromising the crop productivity and soil health.

Dr A.K. Sikka, DDG (NRM) informed that organic farming has advantages over chemical management in agriculture, but considering the food requirement in terms of quantity and quality, proper policy needs to be designed for organic farming after taking in to consideration of crop productivity in different regions.

Shri Ashok Dalwai, Additional Secretary (INM) in his opening remarks informed that organic farming in the country is being promoted through *Paramparaghat Krishi Vikas Yojana* with a target of creating 10,000 clusters. Crop productivity under organic farming is a major concern and considering the food security issue, proper policy of promoting organic farming in the country is essential.

Dr J.P. Singh, Director (Acting), ICAR-IIFSR welcomed the participants while Dr N. Ravisankar, Principal Scientist & National PI, NPOF presented an overview of results of NPOF especially on crop productivity and soil health along with policy input.

After the detailed deliberations, recommendations for promotion of organic farming were finalized besides identification of researchable issues.

Recommendations

1. Organic farming should be promoted in phased manner by identifying niche areas and crops. “Certified organic farming” with combination of tradition, innovation and scientific organic packages should be promoted in the de-facto organic areas (hills) and rainfed/ dryland regions for safe food security and climate resilience, besides increased income of farm households.
2. Accelerated adoption of “towards organic” (integrated crop management) approach for intensive agricultural areas (food hubs)will positively contribute to the cause of soil, human, livestock and eco-system health, the basic objective of organic agriculture.
3. Low volume high value crops should be given impetus for promotion under organic farming especially for export economy.
4. Based on research studies in scientific organic management under ICAR-Network Project on Organic Farming, 18 crops responded positively to yield on par or higher under organic systems after the conversion period (2-3 years). Organic management of basmati rice, rice, maize, green gram, chickpea, soybean, cotton, garlic, cauliflower, tomato resulted in yield advantage to the tune of 4 to 14 % over inorganic management. The scientific Package of PracticesPoP’sfor organic production of crops should be adopted for keeping the crop productivity at comparable or higher level and should be advocated through development schemes.
5. Yield reduction (after 8th cycle across the locations) of 5-8 % was observed in wheat, radish, potato etc. In wheat, 7 % reduction in yield was noticed over the years. Hence, organic farming should not be initiated with exhaustive cropsespecially in winter in the input intensive areas.However under rainfed conditions, wheat yield was comparable. Therefore, if wheat is taken in cropping systems for organic farming, it is better to take durum wheat. Reason for reduction in yield was found to be non-synchronization of nutrient release and critical stage of crop demand.
6. Area specific best cropping systems suitable for organic farming should be mapped for upscaling.

7. Cost of production per unit area is comparable or less under organic agriculture than inorganic management when on-farm organic inputs are used. However, if organic inputs from outside the farm are purchased and utilized, the cost of production increases by about 13 %. Therefore, organic agriculture should naturally depend on on-farm generation of inputs including mixed cropping, crop rotation, residue recycling, composting etc.
8. Integrated Organic Farming System (IOFS) models promises to meet 70-80 % of organic inputs within the farm and should be given impetus for promotion.
9. High volumes of organic materials are required to meet the nutrient demand for organic production. Through combination of sources, the nutrient demand can be met instead of single source and cropping system approach involving green manures and leguminous crops must be adopted. Combination of vermicompost, FYM and neem cake was found to be better compared to application of single source.
10. Decentralization/community based organic input production at local level should be promoted and need to be linked with Swacch Bharat, SHG's etc which will lead to development of micro enterprises and self-employment for youths.
11. Continuous practice of raising the crops organically has good potential to sequester the C (up to 63 % higher C stock in 10 years), higher soil organic carbon (22 % increase in 6 years), reduction in energy requirement (by about 10-15 %) and increase in water holding capacity (by 15-20 %), thereby promoting climate resilience farming.
12. Considering the advantages of organic farming, suitable market and premium price for organic produce needs to be ensured.

Research and Development

1. Although techniques of cultural and mechanical options are available for weed management, present technologies of weed management are labour intensive. Hence, weed management study should be further strengthened in collaboration with ICAR-Directorate of Weed Research, Jabalpur.
2. Regional level consultation meet with successful organic growers should be organized and their goodpractices need to be documented and validated.

3. Staggered N management involving split application of organic manures should be studied at selected locations to match the nutrient release and crop demand.
4. Farm mechanization techniques especially for small organic farm holders needs to be developed.
5. Region specific Integrated Organic Farming System (IOFS) models with zero external cost need to be developed for large scale promotion.
6. Sensitization of SAU’s Scientists on organic farming is required by organizing a National level dialogue by DAC&FW in collaboration with ICAR.
7. Capacity building of researchers involved in organic farming especially at international level needs to be looked into.

CHAPTER 8

Technologies Recommended for Up-Scaling in XI Annual Group Meeting of NPOF

A. Technologies for up-scaling

1. Application of 75 % nutrients only through combination of organics such as FYM, vermicompost, non edible oil cakes and other locally available sources + 2 innovative inputs such as cow urine, panchagavvya, PGPR with complete organic management for following locations and cropping systems.

State	Crop/cropping System
Chhattisgarh	Soybean-pea, soybean-chilli
Himachal Pradesh	Okra-pea-tomato (Summer)
Jharkhand	Rice (Basmati type)-wheat
Karnataka	Greengram-sorghum
Madhya Pradesh	Soybean-wheat, soybean-mustard, soybean-chickpea, soybean-linseed
Punjab	Green manure-basmati rice-chickpea
Uttar Pradesh	Green manure -basmati rice-mustard
Uttarakhand	Green manure -basmati rice-vegetable pea + coriander (4:2 rows)

2. Application 100 % nutrients through combination of organics such as FYM, vermicompost, Non edible oil cakes with complete organic management for following locations and cropping systems.

State	Crop/cropping System
Jharkhand	Rice (Basmati type)-potato, Rice (Basmati type)-linseed
Kerala	Black pepper
Maharashtra	Rice-groundnut
Meghalaya	Rice in sunken beds and French bean and tomato in raised beds
Punjab	GM-basmati rice-wheat; soybean-wheat
Uttarakhand	GM-basmati rice-chickpea + coriander (4:2 rows) GM-basmati rice-potato

3. Towards organic approach with 75 % organic + 25 % inorganic package and 50 % organic + 50 % inorganic package for the following cropping systems and states.

State	Crop/cropping System
Himachal Pradesh	Blackgram-cauliflower-summer squash; Cauliflower-frenchbean
Kerala	Turmeric
Maharashtra	Rice-mustard, Rice-dolichos bean
Meghalaya	Rice in sunken beds and Brocoli, potato & carrot in raised beds
Tamil Nadu	GM-beetroot-maize; GM-cotton-maize; GM-chilli-sunflower

4. Identified varieties of crops for organic farming in different seasons and states.

Location (State)	Season	Crop	Variety
Himachal Pradesh	*Kharif*	Okra	Chameli 015 Indranil
	Rabi	Pea	Ten plus Nirali
		Cauliflower	US-178 Chandra mukhi
	Summer	Tomato	Red Gold Hybrid 7730
Madhya Pradesh	*Kharif*	Soybean	RVS-2002-4 JS-20-41
		Maize	Kanchan-101 Proagro-4412
	Rabi	Wheat	GW-366 HI-8498
		Chickpea	JG-130 RVG-203
Kerala	*Kharif*	Turmeric	Sudarsana Suvarna
		Black pepper	Sreekara Panniyur 1
Tamil Nadu	*Rabi*	Rice	CB 05022 Mappillai samba (Traditional variety)

Location (State)	**Season**	**Crop**	**Variety**
Karnataka	*Rabi*	Chickpea	BGD 103
			JAKI 9218
		Wheat	UAS 347 (Bread wheat)
			NIAW 1415 (Bread wheat)
Maharashtra	*Kharif*	Rice	Sahyadri-5
			Sahyadri-3
		Groundnut	KonkanGaurav
			TG-26
Punjab	*Kharif*	Basmati rice	Pusa Basmati 1509
			Pusa Basmati 1121
	Rabi	Wheat	PBW 621
			PBW 644
Uttar Pradesh	*Kharif*	Maize	PMH -4
			Seed Tech-2324
	Rabi	Mustard	RGN – 229
			RH - 0406
Uttarakhand	*Kharif*	Rice	NDR-359
			Pant Basmati 1
	Rabi	Wheat	HD-2967
			UP-2565
Chhatisgarh	*Kharif*	Rice	Jayagundi
			CR Sugandhdhan- 907
	Rabi	Chickpea	Vijay
			Daftari-21
Jharkhand	*Kharif*	Rice	MTU-10
			Lalat
	Rabi	Wheat	K-0307
			Raj-4229
Meghalaya	Pre-*Kharif*	Maize	DA-61-A
			RCM-75
	Kharif	French bean	Naga local
			RCM FB 18
	Summer	Tomato	MT 2
			Q-17

5. Resource conservation practices for organic farming.

Cropping System	Land configuration
Karnataka	
Soybean-Wheat	BBF with crop residues
Groundnut + Cotton (2:1)	Conventional FB with crop residues
Greengram-Sorghum	Conventional FB without crop residues
Soybean + Pigeonpea (2:1)	BBF with crop residues
Uttarakhand	
Direct seeded rice -chickpea– greengram in BBF	Direct seeded rice with chickpea on broad bed (105 cm x 45 cm)
Meghalaya	
Carrot- Okra	Raised bed
Rice (Lampnah) -Pea	Sunken bed

6. Integrated Organic Farming System (IOFS) models.

Tamil Nadu

Field crop based system (Green manure-cotton-sorghum; Okra + coriander-maize + cowpea (fodder), desmanthus, 1 milch cow, 1 heifer & 1bull calf + vermicompost + boundary plantations (*Gliricidia, coconut*)

Meghalaya

Field & horticulture based system (Cereals + pulses + vegetables +fruits + fodder) + Dairy (1 cow + 1 calf) + fishery + vermicompost

B. Policy issues to be addressed

1. Accelerated adoption of "towards organic" (integrated crop management) approach for intensive agricultural areas (food hubs) and "certified organic farming" with combination of tradition, innovation and science in the de-facto organic areas (hills) and rainfed/ dryland regions will contribute towards safe food security and climate resilience, besides increased income of farm households.

2. State variety release and central variety release committees should consider releasing of varieties for organic farming based screening results of NPOF centres. This will lead to multiplication of seeds through various government programmes.

CHAPTER 9

Certification, Labelling and Accreditation Procedures

Certification is a certification process for producers of organic food and other organic agricultural products. In general, any business directly involved in food production can be certified, including seed suppliers, farmers, food processors, retailers and restaurants. Requirements vary from country to country, and generally involve a set of production standards for growing, storage, processing, packaging and shipping that include:

- Avoidance of synthetic chemical inputs (e.g. fertilizer, pesticides, antibiotics, food additives, etc.) and genetically modified organisms;
- Use of farmland that has been free from chemicals for a number of years (often, three or more);
- Keeping detailed written production and sales records (audit trail);
- Maintaining strict physical separation of organic products from non-certified products;
- Undergoing periodic on-site inspections.

Purpose of certification

Organic certification addresses a growing worldwide demand for organic food. It is intended to assure quality and prevent fraud. For organic producers, certification identifies suppliers of products approved for use in certified operations. For consumers, “certified organic” serves as a product assurance, similar to “low fat”, “100% whole wheat”, or “no artificial preservatives”. Certification is essentially aimed at regulating and facilitating the sale of organic products to consumers. Individual certification bodies have their own service marks, which can act as branding to consumers. Most certification bodies operate organic standards that meet the National government’s minimum requirements.

The certification process

In order to certify a farm, the farmer is typically required to engage in a number of new activities, in addition to normal farming operations:

- **Study** the organic standards, which cover in specific detail what is and is not allowed for every aspect of farming, including storage, transport and sale.
- **Compliance** - farm facilities and production methods must comply with the standards, which may involve modifying facilities, sourcing and changing suppliers, etc.
- **Documentation** - extensive paperwork is required, detailed farm history and current set-up, and usually including results of soil and water tests.
- **Planning** - a written annual production plan must be submitted, detailing everything from seed to sale: seed sources, field and crop locations, fertilization and pest control activities, harvest methods, storage locations, etc.
- **Inspection** - annual on-farm inspections are required, with a physical tour, examination of records, and an oral interview.
- **Fee** – Fee is to be paid by the grower to the certification body for annual survellence and for facilitatining a mark which is acceptable in the market as symbol of quality.
- **Record-keeping** - written, day-to-day farming and marketing records, covering all activities, must be available for inspection at any time.
- In addition, short-notice or surprise inspections can be made, and specific tests (e.g. soil, water, plant tissue analysis) may be requested. For first-time farm certification, the soil must meet basic requirements of being free from use of prohibited substances (synthetic chemicals, etc) for a number of years. A conventional farm must adhere to organic standards for this period, often, three years. This is known as being in *transition*. Transitional crops are not considered fully organic. A farm already growing without chemicals may be certified without this delay.
- Certification for operations other than farms is similar. The focus is on ingredients and other inputs, and processing and handling conditions. A transport company would be required to detail the use and maintenance of its vehicles, storage facilities, containers,

and so forth. A restaurant would have its premises inspected and its suppliers verified as certified organic.

Certification system in India

In India, there are two accreditation systems for authorizing Certification and inspection agencies for organic certification. National Programme on organic Production (NPOP) promoted by Ministry of Commerce is the core programme which governs and defines the standards and implementing procedures. National Accreditation Body (NAB) is the apex decision making body. Certification and inspection agencies accredited by NAB are authorized to undertake certification process. The NPOP notified under FTDR act and controlled by Agricultural Processed Foods Export Development Authority (APEDA) looks after the requirement of export while NPOP notified under APGMC act and controlled by Agriculture Marketing Advisor, Directorate of marketing and inspection looks after domestic certification. Currently 28 certification agencies have been authorized to undertake certification process. In 2006, India's organic certification process under NPOP has been granted equivalence with European Union and Switzerland. It has also been recognized for conformity assessment by USDA's national organic programme.

National Programme on Organic Production

National Program on Organic Production was launched during 2001 under the Foreign Trade & Development Act (FTDR Act). The document provides information on standards for organic production, systems criteria, and procedures for accreditation of Inspection and Certification bodies, the national organic logo and the regulations governing its use.

Scope

The NPOP shall, among others, include: (i) Policies for development and certification of organic products, (ii) National standards for organic products and processes, (iii) Accreditation of programmes to be operated by Inspection and Certification Agencies and (iv) Certification of organic products.

Operational Structure

National Steering Committee for National Programme for Organic Production, is the apex policy making body and operates the entire programme through National Accreditation Body (NAB), Technical Committee (TC) and Evaluation Committee (EC). Agricultural and Processed Food Products Export Development Authority (APEDA) is the secretariat and implementation office for NPOP for export while Agriculture Marketing Advisor, Directorate of Marketing and Inspection, Department of Agriculture and Cooperation is the secretariat and implementation office for NPOP for domestic certification.

National Standards for Organic Production (NSOP)

National Standards for Organic Production are grouped under following six categories:

1) Conversion
2) Crop production
3) Animal husbandry
4) Food processing and handling
5) Labeling
6) Storage and transport

Standard requirements for crop production, food processing and handling are listed below:

1. Conversion Requirements

The time between the start of organic management and cultivation of crops or animal husbandry is known as the conversion period. All standard requirements should be met during conversion period. Full conversion period is not required where organic farming practices are already in use.

2. Crop Production

Choice of crops and varieties: All seeds and planting materials should be certified organic. If certified organic seed or planting material is not available then chemically untreated conventional material can be used. Use of genetically engineered seeds, pollen, transgenic plants are not allowed.

Duration of conversion period: The minimum conversion period for plant products, produced annually is 12 months prior to the start of the production cycle. For perennial plants (excluding pastures and meadows) the conversion period is 18 months from the date of starting organic management. Depending upon the past use of the land and ecological situations, the certification agency can extend or reduce the minimum conversion period.

Fertilization policy: Biodegradable material of plant or animal origin produced on organic farms should form the basis of the fertilization policy. Fertilization management should minimize nutrient losses, avoid accumulation of heavy metals and maintain the soil pH. Emphasis should be given to generate and use own on farm organic fertilizers. Brought in fertilizers of biological origin should be supplementary and not a replacement. Over manuring should be avoided. Manures containing human excreta should not be used on vegetation for human consumption.

Pest disease and weed management including growth regulators: Weeds, pests and diseases should be controlled preferably by preventive cultural techniques. Botanical pesticides prepared at farm from local plants, animals and microorganisms are allowed. Use of synthetic chemicals such as fungicides, insecticides, herbicides, synthetic growth regulators and dyes are prohibited. Use of genetically engineered organisms or products is prohibited.

Soil and Water conservation: Soil and water resources should be handled in a sustainable manner to avoid erosion, salination, excessive and improper use of water and the pollution of surface and ground water. Cleaning of land by burning (e.g. slash and burn and straw burning) should be restricted. Clearing of primary forest for agriculture (jhuming or shifting cultivation) is strictly prohibited.

3. Collection of non-cultivated material of plant origin and honey

Wild harvested products shall only be certified organic, if derived from a stable and sustainable growth environment and the harvesting shall not exceed the sustainable yield of the ecosystem and should not threaten the existence of plant or animal species. The collection area should not be exposed to prohibited substances and should be at an appropriate distance from conventional farming, human habitation, and places of pollution and contamination.

4. Food processing and handling

General principles: Organic products shall be protected from co-mingling with nonorganic products, and shall be adequately identified through the whole process. Certification programme shall regulate the means and measures to be allowed or recommended for decontamination, clearing or disinfection of all facilities where organic products are kept, handled, processed or stored. Besides storage at ambient temperature the following special conditions of storage are permitted.

Pest and disease control: For pest management and control following measures shall be used in order of priority Preventive methods such as disruption, and elimination of habitat and access to facilities. Other methods of pest control are: Mechanical, physical and biological methods Permitted pesticidal substances as per the standards and Other substances used in traps. Irradiation is prohibited. Direct or indirect contact between organic products and prohibited substances (such as pesticides) should not be there.

5. Packaging

Material used for packaging shall be ecofriendly. Unnecessary packaging material should be avoided. Recycling and reusable systems should be used. Packaging material should be biodegradable. Material used for packaging shall not contaminate the food.

6. Labelling

When the full standard requirements are met, the product can be sold as “Organic”. On proper certification by certification agency “India Organic” logo can also be used on the product.

7. Storage and transport

Products integrity should be maintained during storage and transportation of organic products. Organic products must be protected from co-mingling with non-organic products and must be protected all times from contact with the materials and substances not permitted for use in organic farming.

Grower Group Certification System

This system is based on the internal quality system and shall apply to producer groups, farmer's cooperatives, contract production and small scale processing units. The producers in the group must apply similar production systems and the farms should be in geographical proximity.

Constitution of group

The group should have a legal status or constitution of the organization and shall be presented by an organizational chart.

Internal quality system (IQS)

Group certification is based on the concept of an Internal Quality System comprising of the following: -

- Implementation of the internal control system
- Internal standards
- Risk assessment.

An external inspection and certification body should be identified for conducting annual inspection of the individual group / unit. The external inspection agency shall evaluate by checking the IQS documentation, staff qualifications and re-inspecting some farms.

Developing IQS

The following are the minimum requirements for setting up an IQS for grower groups:

- Development of Internal Control System (ICS)
- Identification of producer groups
- Creation of awareness about group certification
- Identification of qualified personnel for maintaining the internal control system
- Give necessary training in production and IQS development
- Preparation of IQS manual containing policies and procedures
- Implementation of the policies and procedures
- Review and improvement of the IQS document for maintaining a harmonized IQS.

Certification Procedure in brief

- Application is made to the certification agency in the prescribed format with necessary farm and process details
- Screening of application by certification agency and if necessary further details/ clarification sought
- Cost estimate comprising of certification charge, inspection charge, travel cost, reporting cost, laboratory charges etc. is sent for acceptance
- Acceptance of cost by the grower/producer
- Signing of agreement between grower/producer and certification agency
- Certification agency seeks cropping/production/cultivation /processing plan and supply a copy of the standards to the grower/producer to follow
- Certification agency raises an invoice and asks the producer to release
- 50% of the certification cost in advance
- Grower/producer pays the fee
- Inspection schedule is worked out

- Inspection is carried out at one or more than one occasion
- If required unannounced inspection can also be done. In case of doubt the inspection team can also draw plant/soil/raw material/input/product sample for laboratory analysis.
- Inspection report/(s) submitted to the certification committee
- Certification agency asks for final payment
- Final payment is made
- Certification is granted
- Grower/producer releases the stock for sale with Certification Mark (India Organic Logo)

Legal framework and policy of organic agriculture

India organic logo for export

National Programmefor Organic Production (NPOP) launched by the Ministry of Commerce during 2001 and National Project on Organic farming (NPOF) launched during 2004 by the Department of Agriculture and Cooperation, Ministry of Agriculture were the two milestones towards institutionalization of organic farming in the country. National Programmefor Organic Production (NPOP) was initiated in the year 2001 to provide a focused and well directed development of organic agriculture and quality products under the Ministry of Commerce and Industry, Government of India which was formally notified in October 2001 under the Foreign Trade & Development Act (FTDR Act). It provides information on standards for organic production, systems criteria, and procedures for accreditation of inspection and certification bodies, the national organic logo and the regulations governing its use. The standards and procedures have been formulated in harmony with international standards such as those of Codex and IFOAM. The NPOP provides an institutional mechanism for the implementation of National Standards for Organic Production, through a National Accreditation Policy and Program. National Accreditation Body (NAB) is the apex decision making body. Certification and inspection agencies accredited by NAB are authorized to undertake certification process. The NPOP notified under FTDR act and controlled by Agricultural Processed Foods Export Development Authority (APEDA) looks after the requirement of export while Organic Agricultural Produce

Grading and Marking Rules, 2009 notified under Agricultural Produce (Grading & Marking) act, 1937 controlled by Agriculture Marketing Advisor, Directorate of marketing and inspection looks after domestic certification. Efforts are on to have NPOP standards to be included under the Food Safety and Standards Act, 2006. In 2006, India's organic certification process under NPOP has been granted equivalence with European Union and Switzerland. It has also been recognized for conformity assessment by USDA's national organic production. The standards for aquaculture, animal husbandry and textiles approved by the National Steering Committee for organic products and are expected to be notified by Directorate General of Foreign Trade (DGFT) shortly.

Participatory Guarantee System (PGS)

Low cost alternative certification namely grower group certification (GGC) and participatory guarantee systems (PGS) were also introduced and being adopted largely in the Paramparagat Krishi Vikas Yojana (PKVY) sheme for promotion of organic farming in the country. Participatory Guarantee System (PGS) is a quality assurance initiative that is locally relevant,emphasize the participation of stakeholders, including producers and consumers and operateoutside the frame work of third party certification. As per IFOAM (2008) definition"Participatory Guarantee Systems are locally focused quality assurance systems. They certify producers based on active participation of stakeholders and are built on a foundation of trust,social networks and knowledge exchange". PGS is a process in which people in similarsituations (in this case small holder producers) assess, inspect and verify the productionpractices of each other and take decision on organic certification (PGS-Green and PGSOrganic).PGS system has number of basic elements which embrace a participatory approach, a sharedvision, transparency and trust. Participation is an essential and dynamic part of PGS. Keystakeholders (producers, consumers, retailers, traders and others such as NGOs, Societies/Gram panchayaths/ State/Central Govt. organization/agencies /farmer etc.,) are engaged inthe initial design, and then in the operation of the PGS. In the operation of a PGS,stakeholders (including producers) are involved in decision making and essential

PGS logo for marketing under conversion (green) and after conversion (Blue)

decisionsabout the operation of the PGS itself. In addition to being involved in the mechanics of thePGS, stakeholders, particularly the producers are engaged in a structured ongoing learningprocess, which helps them improve what they do. This process is facilitated by the PGSgroup itself or in some situations a supportive NGO/ Societies, Gram panchayaths,State/ Central Govt. organization/agencies etc. The learning process is usually „hands-on andinvolves field days or workshops. The idea of participation embodies the principle ofcollective responsibility for ensuring the organic integrity of the PGS.

In PGS organic farmers have full control over the certification process and are able toproduce far more credible and effective system of quality assurance compared to third party PGS-INDIA certification. Important benefits of this system over third party certification system are as follows:

- The procedures are simple; documents are basic and use the local language understandable to farmers.
- All the members are local and known to each other. Being themselves practicing organic farmers have high degree of understanding on day-to-day knowledge or acquaintance of the farm.
- Peer appraisers are among the group and live in the same village, therefore have betteraccess to surveillance.
- Peer appraisal instead of third party inspections reduces cost.
- Mutual recognition and support between Regional PGS groups ensures better networking for processing and marketing.
- Empowers farmers with increased capacity building.
- Bring consumers to the farm without the need of middleman.
- Unlike grower group certification system, PGS offer every farmer with individual certificate and each farmer is free to market its own produce independent of group.
- Consumers and buyers are often involved in production and verification process.
- Random residue testing at regular intervals ensures the integrity and increases the trust.

Products for Use in Fertilising and Soil Conditioning

In organic agriculture the maintenance of soil fertility may be achieved through the recycling of organic material whose nutrients are made available to crops through the action of soil micro-organisms and bacteria.

Many of these inputs are restricted for use in organic production. In this appendix "restricted" means that the conditions and the procedure for use shall be set by the certification programme. Factors such as contamination, risk of nutritional imbalances and depletion of natural resources shall be taken into consideration.

Matter Produced on an Organic Farm Unit

• Farmyard & poultry manure, slurry, urine	Permitted
• Crop residues and green manure	Permitted
• Straw and other mulches	Permitted

Matter Produced Outside the Organic Farm Unit

• Blood meal, meat meal, bone meal and feather meal without Preservatives	Restricted
• Compost made from any carbon based residues (animal excrement including poultry)	Restricted
• Farmyard manure, slurry, urine	Restricted (preferably after control fermentation and / or appropriate dilution) "factory" farming sources not permitted.
• Fish and fish products without preservatives	Restricted
• Guano	Restricted
• Human excrement	Not allowed

By-products from the food and textile industries of biodegradable material of microbial, plant or animal origin without any synthetic additives	Restricted
Peat without synthetic additives (prohibited for soil conditioning)	Permitted
Sawdust, wood shavings, wood provided it comes from untreated wood	Permitted
Seaweed and seaweed products obtained by physical processes, extraction Aith water or aqueous acid and/or alkaline solution	Restricted
Sewage sludge and urban composts from separated sources which are monitored for contamination	Restricted
Straw	Restricted
Vermicasts	Restricted
Animal charcol	Restricted
Compost and spent mushroom and vermiculate substances	Restricted
Compost from organic household reference	Restricted
Compost from plant residues	Permitted
By products from oil palm, coconut and cocoa (including empty fruit bunch, palm oil mill effluent (pome), cocoa peat and empty cocoa pods)	Restricted
By products of industries processing ingredients from organic agriculture	Restricted

Minerals

Basic slag	Restricted
Calcareous and magnesium rock	Restricted
Calcified seaweed	Permitted
Calcium chloride	Permitted
Calcium carbonate of network origin (chalk, limestone, gypsum and phosphate chalk)	Permitted
Mineral potassium with low chlorine content (e.g. sulphate of potash,	Restricted

kainite, sylvinite, patenkali)	
Natural phosphates (e.g. Rock phosphates)	Restricted
Pulverised rock	Restricted
Sodium chloride	Permitted
Trace elements (baron, In, Fe, Mn, molybolerum, Zn)	Restricted
Woodash from untreated wood	Restricted
Pottassium sulphate	Restricted
Magnesium sulphate (Epson salt)	Permitted
Gypsum (calcium sulphate)	Permitted
Stillage and stillage extract	Permitted
Aluminum calcium phosphate	Restricted
Sulphur	Restricted
Stone mill	Restricted
Clay (bentonite, perlite, zeolite)	Permitted

Microbiological Prepararations

Bacterial preparations (biofertilizers)	Permitted
Biodynamic preparations	Permitted
Plant preparations and botanical extracts	Permitted
Vermiculate	Permitted
Peat	Permitted

"Factory" farming refers to industrial management systems that are heavily reliant on veterinary and feed inputs not permitted in organic agriculture.

Products for Plant Pest and Disease Control

Certain products are allowed for use in organic agriculture for the control of pests and diseases in plant production. Many of these products are restricted for use in organic production. Such products should only be used when absolutely necessary and should be chosen taking the environmental impact into consideration.

In this appendix “restricted” means that the conditions and the procedure for use shall be set by the certification programme.

I. Substances from plant and animal origin

Azadirachta indica [neem preparations (neem oil)]	Restricted
Preparation of rotenone from *Derris elliptica, Lonchocarpus, Thephrosia spp.*	Restricted
Gelatine	Permitted
Propolis	Restricted
Plant based extracts (e.g. neem, garlic, pongamia, etc.)	Permitted
Preparation on basis of pyrethrins extracted from *Chrysanthemum cinerariaefolium*, containing possibly a synergist pyrethrum cinerafolium	Restricted
Preparation from Quassia amara	Restricted
Release of parasite predators of insect pests	Restricted
Preparation from Ryania species	Restricted
Tobacco tea	Not allowed
Lecithin	Restricted
Casein	Permitted
Sea weeds, sea weed meal, sea weed extracts, sea salt and salty water	Restricted
Extract from mushroom (Shiitake fungus)	Permitted
Extract from Chlorella	Permitted
Fermented product from Aspergillus	Restricted
Natural acids (vinegar)	Restricted

II. Minerals

Chloride of lime/soda	Restricted
Clay (e.g. bentonite, perlite, vermiculite, zeolite)	Permitted
Copper salts / inorganic salts (Bordeaux mix, copper hydroxide, copper oxychloride) used as a fungicide, maximum 8 kg per ha per year depending upon the crop and under the supervision of inspection and certification agency	Restricted
Mineral powders (stone meal, silicates)	Not allowed
Diatomaceous earth	Restricted
Light mineral oils	Restricted
Permanganate of potash	Restricted
Lime sulphur (calcium polysulphide)	Restricted
Silicates (sodium silicate, quartz)	Restricted
Sodium bicarbonate	Permitted
Sulphur (as a fungicide, acaricide, repellent)	Restricted

III. Microorganisms / Biocontrol agents

Viral preparations (e.g., Granulosis viruses, Nuclear polyhydrosis, viruses etc.).	Permitted
Fungal preparations (e.g., Trichoderma species etc.)	Permitted
Bacterial preparations (e.g., Bacillus species etc.)	Permitted
Parasites, predators and sterilized insects.”	Permitted

IV. Others

Carbon dioxide and nitrogen gas	Restricted
Soft soap (potassium soap)	Permitted

Ethyl alcohol	Not allowed
Homeopathic and Ayurvedic preparations	Permitted
Herbal and biodynamic preparations	Permitted

V. Traps

Physical methods (e.g., chromatic traps, mechanical traps, light traps, sticky traps and pheromones)	Permitted
Mulches, nets	Permitted

List of Approved Feed Materials, Feed Additives and Processing Aids for Animal Nutrition

1. Feed Materials of Plant Origin

- Cereals grains, their products and by - products
- Oilseeds, oil fruits, their products and by - products
- Legume seed, their products and by - products
- Tuber roots, their products and by - products
- Other seeds and fruits
- Forages and roughages
- Molasses as a binding agent

2. Feed Material of Animal Origin

- Milk and milk products
- Fish, other marine animals, their products and by - products

3. Feed Material of Mineral Origin

Sea salt, rock salt	Restricted

Sodium sulphate	Restricted
Sodium carbonate	Restricted
Sodium bicarbonate	Restricted
Sodium chloride	Restricted
Calcium carbonate	Restricted
Calcium lactate	Restricted
Calcium gluconate	Restricted
Bone dicalcium phosphat precipitate	Restricted
Defluorinated dicalcium phosphate	Restricted
Defluorinated monocalcium phosphate	Restricted
Anhydrous magnesia	Restricted
Magnesium sulphate	Restricted
Magnesium chloride	Restricted
Magnesium carbonate	Restricted

4. Trace Elements

Iron	Feed additives
Iodine	Feed additives
Cobalt	Feed additives
Manganese	Feed additives
Zinc	Feed additives
Molydenum	Feed additives
Selenium	Feed additives

5. Vitamins

Restricted

6. Enzymes

Restricted

7. Micro-organisms

Restricted

8. Preservatives for silage

- E-336 Formic acid
- E-260 Acetic acid
- E-270 Lactic acid
- E-280 Propionic acid

9. Binders, anti-caking agent and coagulants

- E-551b Colloidal silica
- E-551c Kieselgur
- E-553 Sepiolite
- E-558 Bentonite
- E-559 Kaolinitic clays
- E-561 Vermiculite
- E-599 Perlite

10. Processing aids for silage

- Sea salt
- Coarse rock salt
- Enzymes
- Yeasts
- Sugar
- Sugar beet pulp
- Cereal flour
- Molasses
- Lactic

Products Authorized for Cleaning and Disinfection of Livestock Buildings and Installations

- Potassium and sodium soap
- Water and steam
- Milk of lime
- Lime
- Quicklime
- Sodium hypochlorite (e.g. as liquid bleach)
- Caustic potash
- Hydrogen peroxide
- Natural essences of plants
- Citric, peracetic acid, formic, lactic, oxalic and acetic acid
- Alcohol
- Nitric acid (dairy equipment)
- Phosporic acid (dairy equipment)
- Formaldehyde
- Sodium carbonate

Government Schemes to promote organic farming

1. Paramparaghat Krishi Vikas Yojana (PKVY)
2. Mission Organic Value Chain Development for North Eastern region (MOVCD-NEH)

more details can be obtained from http://www.agricoop.nic.in/divisiontype/integrated-nutrient-management.

List of Accredited Certification Bodies under NPOP

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
1	Bureau Veritas Certification India (BVCI) Pvt. Ltd.	**Contact Person**: Mr. Kaushik Sengupta Product Manager (Food -India) **Address:** Marwah Centre, 6th Floor Opp. Ansa Industrial Estate Krishanlal Marwah Marg Off Saki-Vihar Road Andheri (East), Mumbai-400 072 Maharashtra Tel. No: 022-66956300, 56956311 Fax No. 022-66956302/10 Email:kaushik.sengupta@in.bureauveritas.com	NPOP/NAB/001	31-05-19	NPOP USDA NOP	
2	ECOCERT India Pvt. Ltd.	**Contact Person:** Mr. Anil Jadhav Chief Executive Officer **Address:** 1st Floor, Vatika Business Park, Block -2, Sector- 49,Sohna Road, Gurgaon – 122018, Haryana, India Telephone: +91-124-6999959 Email: anil.jadhav@ecocert.com	NPOP/NAB/002	22-08-17	NPOP USDA NOP	

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
3	**IMO Control Pvt. Ltd.**	**Contact Person:** Mr. Umesh Chandrasekhar Director **Address:** No. 3627, 1st Floor, 7th Cross, 13th ' G ' Main, H.A.L. 2nd Stage, Bangalore-560 008. Tel. No: +91-80-25285883, 25201546, 25215780 Fax: 0091-80-25272185 Email: imo@imocontrol.in Web: www.imocontrol.in	NPOP/NAB/003	28-09-16	NPOP USDA NOP	control IMO
4	**Indian Organic Certification Agency (INDOCERT)**	**Contact Person:** Mr. Mathew Sebastian Executive Director **Address:** Thottumugham P.O. Aluva-683 105, Cochin (Kerala) Telefax: 0484-2630908-09/2620943 Email: info@indocert.org Web: www.indocert.org	NPOP/NAB/004	24-10-17	NPOP USDA NOP	INDOCERT
5	**Lacon Quality Certification Pvt. Ltd.**	**Contact Person:** Mr. Bobby Issac Director **Address:** Chenathra, Theepany, Thiruvalla - 689 101 (Kerala) Tel. No: 0469 2606447 Fax: 0469 2631902 Email: info@laconindia.com Web: www.laconindia.com	NPOP/NAB/006	31-10-17	NPOP USDA NOP	lacon QUALITY

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
6	**OneCert Asia Agri Certification (P) Ltd.**	**Contact Person:** Mr. Sandeep Bhargava Chief Executive Officer **Address:** H-08, Mansarovar Industrial Area, Mansarovar Jaipur-302020, Rajasthan Phone & Fax- 0141-2395481, 6541882, 6541883(Direct) Email:- info@onecertasia.in Web site:- www.onecertasia.in	NPOP/NAB/008	26-10-2018	NPOP USDA NOP Livestock w.e.f 08.04.2016	CERTIFIED OneCert ORGANIC
7	**SGS India Pvt. Ltd.**	**Contact Person:** Mr. Amresh Pandey Technical Manager -Organic Certification **Address:** SGS India Pvt Ltd 226,Udyog Vihar, Phase-I Gurgaon-122016 Haryana Tel: + 91 124 6776300 Ext 6379 91 124 6776379 (Direct) Fax: +911246776403/04 Mobile: + 91 9871794709 Email: amresh.pandey@sgs.com	NPOP/NAB/009	01-05-17	NPOP USDA NOP	SGS ORGANIC
8	**Control Union Certifications**	**Contact Person:** Mr. Dirk Teichert Managing Director **Address:** Plot No. C-113, Pawane MIDC, Navi Mumbai - 400709 Tel: +91-22-61294300 Fax:+91-22-61294217 Mobile:09930453754 Email: cuc@controlunion.in Website: www.controlunion.com	NPOP/NAB/0010	28-05-17	NPOP USDA NOP Livestock w.e.f 21.04.2016	CONTROLUNION

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
9	Uttarakhand State Organic Certification Agency (USOCA)	**Conact Person:** Sh. Gauri Shankar Director **Address:** Third Floor, Krishak Bhavan Mussoorie By Pass Ring Road Nehru Gram, Dehradun, Uttarakhand Tel : 0135 2671734 Email: info@usoca.org Website: www.usoca.org	NPOP/NAB/0011	13-11-18	NPOP USDA NOP Livestock w.e.f 08.06.2016	USOCA NPOP/NAB/0011
10	APOF Organic Certification Agency (AOCA)	**Contact Person:** Mr. Mandar B Navare Chief Operating Officer **Address:** Holkar House, First Floor, Sr no: 54, Near Nikhil Garden, Wadgaon Bk. Pune 411041 Phone /fax: 020-65410070 Email: ceo@aoca.in Website: www.aoca.in	NPOP/NAB/0012	09-01-19	NPOP	aoca
11	Rajasthan Organic Certification Agency (ROCA)	**Contact Person:** Mr. Madhu Sudan Sharma Director **Address:** 3rd Floor, Pant Krishi Bhawan, Janpath, Jaipur 302 005 Rajasthan Tel. No.: 0141-2227104, Tele Fax: 0141-2227456 Email: rocajpr.cb@gmail.com	NPOP/NAB/0013	09-10-16	NPOP USDA NOP (w.e.f 01-07-2015)	RAJASTHAN ORGANIC CERTIFICATION AGENCY. ROCA

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
12	**Vedic Organic Certification Agency**	**Contact Person:** Dr. (Mrs.) M. Usha Managing Director **Address:** Plot no-54,Ushodaya Enclave Mythrinagar, Miyapur Hyderabad-500050 Telangana Phno: 040-65276784 Fax: 040-23045338 Email : voca_org@yahoo.com Website: www.vediccertification.com	NPOP/NAB/0014	30-09-17	NPOP USDA NOP (w.e.f 01-10-2011)	
13	**ISCOP (Indian Society for Certification of Organic Products)**	**Contact Person:** Prof: Dr. K. K. Krishnamurthi President **Address:** Indian Society for Certification of Organic Products (ISCOP) 135, Ponnurangam Road West R.S. Puram, Coimbatore-641002 Tamil Nadu Phone:0422-2544199/ 0422-2546160 Mobile:91 94432 43119 Email: profdrkkk@yahoo.com Website:www.iscoporganiccertification.org	NPOP/NAB/0015	30-09-17	NPOP	

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
14	**Food Cert India Pvt. Ltd**	**Contact person:** Mr. K. K. Gupta Director **Address:** A Wholly Owned Subsidiary of Tata Projects Limited Fourth Floor, Mithona Towers-I, 1-7-80 to 87, Prenderghast Road, Secunderabad - 500 003, Telangana, India Tel : +91 - 40 – 65181222 Fax: +91 – 40 - 66172535 Email: kkgupta@foodcert.in Website: www.foodcert.in	NPOP/NAB/0016	30-09-17	NPOP USDA NOP (w.e.f 1-6-2011)	FOOD CERT
15	**Aditi Organic Certifications Pvt. Ltd**	**Contact person:** Mr. Narayana Upadhyaya Director **Address:** Aditi Organic Certifications Pvt. Ltd. No. 38, 1st Floor, 20th Main Road, First Block, Rajajinagar, Bengaluru-560010 Tel.: +91-080 23328134/35/36 Fax: +91-80-23373083 Mobile: +91-9845064286 Email: aditiorganic@gmail.com Website: www.aditicert.net	NPOP/NAB/0017	30-09-17	NPOP USDA NOP (w.e.f 1-6-2010)	ADITI
16	**Chhattisgarh Certification Society, India (CGCERT)**	**Contact person:** Dr. A.A. Boaz (IFS) Chief Executive Officer **Contact address:** Campus SFRTI Near Vidhan Sabha Zero point, Baloda Bazar Road, Raipur, Chhattisgarh 493 111 Tel: +91-771-2283249 Fax : +91-771-2283249 Email: cgcert@gmail.com	NPOP/NAB/0018	15-09-18	NPOP	CGCERT

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
17	**Tamil Nadu Organic Certification Department (TNOCD)**	**Contact person:** Mr. R. Jayasundar Director **Contact address:** 1424 A, Thadagam Road G.C.T Post, Coimbatore – 641013 Tamil Nadu Tel.: 0422 2435080 Fax: 0422 2457554 Email: tnocdcbe@gmail.com Website: www.tnocd.net	NPOP/NAB/0019	30-09-18	NPOP	
18	**Intertek India Pvt. Ltd.**	**Contact Person:** Mr. Ashish Gaur Head - Certification (Food Services) **Address:** E-20, Block B-1 Mohan Cooperative Industrial Estate Mathura Road New Delhi - 110 044 Ph : +91-11-4159 5420/ +91 9899461610 Fax : +91-11-4159 5475 E-mail : ashish.gaur@intertek.com Website : www.intertek.com	NPOP/NAB/0020	19-05-19	NPOP USDA NOP (w.e.f 01-10-2011)	Intertek
19	**Madhya Pradesh State Organic Certification Agency**	**Contact Person:** Mr. Ajay Gupta (IAS) Managing Director **Address:** Vasundhara, B-II Office Complex Gautam Nagar Bhopal 462 023 Madhya Pradesh Tel : 0755 2600609 E-mail : md.mpsoca@gmail.com	NPOP/NAB/0022	30-09-17	NPOP **(w.e.f 01-10-2011)**	mpsoca

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
20	**Odisha State Organic Certification Agency (OSOCA)**	**Contact Person:** Mr. Aditya Kumar Patra Quality Manager **Address:** Plot No.-326, Baramunda, Bhubaneswar, Odisha, 751003 Phone-(0674) 2563639/2561783 Fax.- (0674)2562078 Mobile No.- 9437211001 Email : ceoosoca@gmail.com directorossca@rediffmail.com Website : www.ossopca.org	NPOP/NAB/0025	31-05-18	NPOP	
21	**Natural Organic Certification Agro Pvt. Ltd.**	**Contact Person:** Mr. Sanjay Deshmukh Managing Director **Address:** Office No.2 Karan Plaza-II Near Rozary School Warje Pune - 411058 Maharashtra State Tel- 91-20-65218063 Cell no. 09822006586 E mail-nocaindia@gmail.com Web site: www.nocaagro.com	NPOP/NAB/0026	14-02-17	NPOP	NOCA
22	**Fair Cert Certification Services Pvt. Ltd.**	**Contact Person:** Dr. Pushkar Kulshrestha CEO **Address:** C-122, Gauridham Colony Khargone Madhya Pradesh 451001 Tel : +91-7282-231271/203017 Fax : +91-7282-231271 E-mail: cert.fair@gmail.com Website: www.faircert.com	NPOP/NAB/0027	14-02-17	NPOP	FAIR CERT

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
23	**Gujarat Organic Products Certification Agency (GOPCA)**	**Contact Person:** Shri R. A Oza Quality Manager **Address:** Beej Pramanan Bhavan Opp. Gokul House Nr. Shyamal Cross Rd, Satellite Ahmedabad- 380015, Gujarat Tel : +079-26740031 Fax : +079-26740031 E-mail: dirgopca@gmail.com Website: www.gopca.in	NPOP/NAB/0028	19-06-17	NPOP (w.e.f 20.06.2014)	
24	**Uttar Pradesh State Organic Certification Agency**	**Contact Person:** Mr. Chandra Kishore Mishra Joint Director **Address:** Government Garden Campus Kariyappa Road, Alambagh Lucknow 226 005 Uttar Pradesh Tel : +91 – 0522 – 2451639 Mobile : +917317001283 E-mail: upsoca.org@gmail.com Website: www.upsoca.org	NPOP/NAB/0029	19-06-17	NPOP (w.e.f 20.06.2014)	
25	**Karnataka State Organic Certification Agency**	**Contact Person:** Mr. S.S. Parashiva Murthy Deputy Director **Address:** Opp. Bellary Hospital, Bellary Road Hebbal, Bengaluru 560 024 Tel : +91 – 80- 23418302 FAX : +91 – 80 - 23415506 E-mail: ksocabng@gmail.com Website: www.kssoca.in	NPOP/NAB/0030	16-08-18	NPOP (w.e.f 17.08.2015)	

Sr. No.	Name of the Certification Agency	Contact Person & Address	Accreditation No.	Validity of Current Accreditation	Scope of Accreditation	Certification Mark
26	**Sikkim State Organic Certification Agency (SSOCA)**	**Contact Person:** Dr. Yashoda Pradhan CEO **Address:** Ground Floor, Soil Testing Lab Building, ICAR Complex, Tadong, Gangtok, Sikkim 737102 Tel : +91 – 03592-232494 FAX : +91 – 03592-232495 E-mail: ssoca2016@gmail.com Website: www.ssoca.in	NPOP/NAB/0031	02-10-19	NPOP (w.e.f 03.10.2016)	
27	**Global Certification Society**	**Contact Person:** Dr. H.L. Sharma Chairman **Address:** House No. 212, Ward No. 3 Main Bazaar, Palampur 176 061 Himachal Pradesh Tel : 01894-234230 Fax: 01894-230131 E-mail: chairman@glocert.org Website: www.glocert.org	NPOP/NAB/0032	02.10.2019	NPOP (w.e.f 03.10.2016)	
28	**Green Cert Biosolutions Pvt. Ltd.**	**Contact Person:** Mr. Neelesh Gharmalkar CEO **Address:** Office 2, Building No.12, Runwal Meadow, Warje Pune 411 052 Tel : +91 – 9922488750 E-mail: greencert.pune@gmail.com	NPOP/NAB/0033	02.10.2019	NPOP (w.e.f 03.10.2016)	

CHAPTER 11

Important Publications and Websites on Organic Farming in Indian Context

Sl. No.	Author (s)/ organization	Year	Title	Published by or in
1.	NAAS	2005	Organic Farming: Approaches and possibilities in the context of Indian Agriculture	National Acdemy of Agricultural Sciences, New Delhi
2.	Ramesh, P., Mohan Singh and A. Subba Rao	2005	Organic Farming: Its relevance to Indian context	Current Science 88 (4):561-568
3.	Bhattacharyya, P and G. Chakraborty	2005	Current status of organic farming in India and other countries	Indian Journal of Fertilizers 1(9):111-123
4.	Narayanan, S	2005	Organic Farming in India: Relevance, Problems and Constraints	Occasional paper-38, NABARD, Mumbai
5.	Venkateswarlu, B., SS Balloli and Y.S. Ramakrishna	2007	Organic Farming in Rainfed Agriculture: Opportunities and constraints	Central Research Institute for Dryland Agriculture, Hyderabad
6.	Yadav, A.K	2008	Organic Agriculture: Concept, Scenario, principles and practices	NCOF, Ghaziabad, New Delhi
7.	Kumara Charayulu, D and Subho Biswas	2010	Organic input production and marketing in India: Efficiency, issues and policies	CMA publication No. 239, Centre for Management in Agriculture, Ahmedabad
8.	ICAR-NPOF	2011	Consolidated Report of NPOF	ICAR-IIFSR, Modipuram
9.	Venkateswarlu, B and JVNS Prasad	2012	Carrying capacity of Indian Agriculture: Issues related to rainfed agriculture	Current Science 102 (6):882-888
10.	Panneerselvam, P, Jhon E Hermanson, Niels Halberg and P. Murali Arthanari	2013	Impact of large-scale conversion on food production and food security in two Indian states, Tamil Nadu and Madhya Pradesh	Renewable Agriculture and Food systems

Sl. No.	Author (s)/ organization	Year	Title	Published by or in
11.	Mohamed Ragab Abdel Gawwad	2013	Status, trends and prospects of organic farming in India: A review	Journal of Plant Biology Research 2(2):38-48
12.	Mahesh Chander	2013	Organic Livestock Farming	ICAR-DKMA, New Delhi
13.	Aman Deep Kumar	2014	Organic Farming for Sustainable Agriculture: Global and Indian perspective	Global journal for research analysis 3(2):57-59
14.	ICAR-NPOF	2014	Package of Practices for organic production of crops in cropping systems perspective	ICAR-IIFSR, Modipuram
15.	Ravisankar, N., Subash Chand and Kamta Prasad	2015	Status and future prospect of organic agriculture for safe food security in India	SAARC Agriculture Centre, Bangladesh
16.	Ravisankar, N., S.K. Sharma, D.K. Singh and A.S. Panwar	2016	Organic Farming in India: Production Issues and strategies	Indian Farming 66 (8):16-23

Comprehensive information portal: www.iifsr.res.in
www.agricoop.nic.in/integrated nutrient management
http://agritech.tnau.ac.in/org_farm/orgfarm_index.html

IMPORTANT WEBSITES

1. www.iifsr.res.in
2. http://agricoop.nic.in/divisiontype/integrated-nutrient-management
3. http://agritech.tnau.ac.in/org-farm/orgfarm-index.html
4. www.ncof.dacnet.nic.in
5. www.pgsindia-ncop.gov.in
6. www.apeda.gov.in/apedawebsite/organic/organic-products.htm

Location of Network Project on Organic Farming

ISBN No. 978-81-928993-3-6

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch