ORGANIC PACKAGE OF PRACTICES FOR SELECTED CROPS OF ASSAM 2023

Published jointly by
Assam Agricultural University, Jorhat &
Department of Agriculture, Assam

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Atul Bora
Minister
Agriculture, Horticulture, Animal Husbandry & Veterinary, Border Protection & Development. Implementation of Assam Accord.

सत्यमेव जयते

GOVERNMENT OF ASSAM

MESSAGE

I am very happy to know that the Assam Agricultural University, Jorhat jointly in association with Department of Agriculture, Government of Assam is going to publish the recent version of the "Package of Practices for Kharif/Rabi/Horticultural Crops of Assam, 2023" along with the "Organic PoP for selected Crops of Assam, 2023" with the inclusion of 59 number of recently developed technologies pertaining to crop improvement, management and protection. I am also happy to know that Assam Agricultural University, Jorhat has developed the "Package of Practices for Climate Resilient Technologies of Assam, 2023" for the first time to combat the adverse effects of climate change on agriculture in the recent times, which will provide impetus to the agricultural growth and development in the state.

Agriculture is the mainstay of the Assam's economy as the majority of the people depend on agriculture and allied activities for their livelihood directly or indirectly. Adoption of sustainable, cost effective and advanced agricultural technologies could help in achieving rapid agricultural growth through optimum utilization of available resources of the state.

I sincerely believe that this Package of Practices, 2023 will be a great help for our extension machineries and farming community to boost up production and productivity of major crops in the state.

I convey my best wishes on this auspicious occasion.

Date : 30th August, 2024

(ATUL BORA)

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MESSAGE

Agriculture plays a vital role in the economy of the state, contributing to about 45% of the State's Gross Domestic Product (SGDP) with an annual growth rate of 8.15% (2021-22). Owing to the availability of fertile soil and abundance of rain, the state provides a favourable environment to produce both food and cash crops. Over 70 percent of the state's population relies on agriculture as farmers, agricultural laborers, or both for their livelihood, which emphasizes the importance of agriculture in the state. Hence, a rapid growth of agriculture could help not only in achieving self-reliance on food grain production but also in attaining food security and to reduce poverty in the state.

I am glad to know that the Assam Agricultural University, Jorhat jointly with the Department of Agriculture, Govt. of Assam is going to publish the Package of Practices for Crops of Assam, 2023 with inclusion of recently developed technologies pertaining to crop improvement, management and protection. I am confident that this will serve as a handbook to empower our extension machineries and farming community towards production and productivity enhancement of the state. I am sure that the package of practices included will be adopted by the farming community of state boosting the agricultural production systems.

With best wishes,

27/8/24.

Date: 27-08-2024

(Smt. Aruna Rajoria, IAS)

Dr. Bidyut C. Deka
Vice Chancellor

ASSAM AGRICULTURAL UNIVERSITY
JORHAT-785013, ASSAM (INDIA)

(Recipient of Sardar Patel Outstanding Institution Award)

Message

I am happy to learn that the Director of Research (Agriculture) of Assam Agricultural University in collaboration with the Department of Agriculture, GoA is bringing out the publication on *'Package of Practices for Kharif, Rabi and Horticultural Crops, 2023 as well as Organic Package of Practices,2023"* wherein a total of 59 new technologies pertaining to crop improvement, management, and protection have been incorporated as per the recommendations of a workshop jointly organized by AAU and Govt. of Assam.

I sincerely believe that the technologies so generated and included in the publication through the dedicated service of the scientists shall be great help to the farmers, scientists and extension functionaries of the state increasing agricultural growth, productivity and farm income.

I place on record my sincere gratitude to the team of scientists associated with the preparation of the manuscript.

(Bidyut C. Deka)

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CEREAL CROPS

Rice (*Oryza sativa*)

Sali rice (winter rice)

Varieties	Year of notification	*Agroclimatic zone	Duration (days)	Sowing time	Avg. plant height (cm)
A. Transplanted normal Sali:					
i) Semi dwarf					
Ranjit	1994	N,U,C,L,B,H	150-155	Mid-June	102
AAU-DPU Dhan 07 (Amreng)	-	N,U,C,L,B,H	140-145	Mid-May – to mid-June	114
ii) Multiple cropping:					
Basundhara	1999	N,U,C,L	130-133	do	107
iii) Tall:					
Mahsuri	-	N,U,C,L,B,H	140-145	Mid-June	130
AAU-DIPHU Dhan 5 (Langpi)	-	N,U,C,L,B,H	140-145	Mid-June	130
iv) Scented Rice:					
Keteki jaha	2006	N,U,C,B	155-165	June	100-140
Kola joha	-	-	-	-	-

N-NBPZ, U-UBVZ, C-CBVZ, L-LBVZ, B-BVZ, H-HZ

Seed Selection:

Seeds should be put in plain water, stirred well, sunken seeds are to be selected and the floated ones are rejected.

Seed Treatment: Treated seeds should be kept for incubation for 48 hr

Raising of seedlings

A. Normal practice:

a) Preparation of seed bed: Land is thoroughly puddled and seed beds of 10 m length and 1.25 m breadth are prepared with 30 cm gap in between the beds. The length of the bed may vary according to convenience.

b) Seed rate:

Well germinated seeds are to be sown @ 650 g to 1 kg per bed depending on grain size. Requirement of seed for transplanting one hectare of main field is 40 to 45 kg.

c) Water Management:

Irrigation water should be applied in furrows to maintain saturated condition in the surface soil of the nursery bed. However, standing water to a depth of 2-3 cm should be maintained at least 2-3 days before uprooting.

B. Mat nursery for mechanical transplanting:

The success of mechanical transplanting (i.e. using self-propelled rice transplanter or manually operated mechanical transplanter) depends upon the quality of seedling. Therefore, all care should be taken to prepare good quality mat nursery. Preparation of mat nursery is described below:

a. Materials required:

Polythene sheet, wooden or iron frame, well pulverized & well- sieved soil, FYM, sprouted and treated paddy seed.

b. Preparation seed:

Seeds are treated as per recommendation and kept immersed in water for one night in a jute bag. Seed bags are taken out of water and kept in open air for sufficient period till the length of sprouting becomes 1-2 mm. Lumps if any are broken gently to ensure uniform distribution.

c. Dimension of plot to accommodate seedling:

A leveled plot of land free from any undulation and grass, etc. should be selected to accommodate seedling bed. Three numbers of beds, with effective length of 16 m and effective width of 1 m, each are needed to prepare seedlings for 1 ha of cropped area. The dimension of the plot should be selected as per the seedling requirement.

d. Frame:

Removable frame is used to ensure uniform mat size. The dimension of the mat frame should be equal to the dimension of the tray of the machine. Wooden bar or mild steel bar (2.5 cm × 0.3 cm) may be used as the boundary of the frame.

e. Preparation of soil-cow dung mixture:

The soil crushed and sieved (particle size less than 4 to 5 mm) is mixed with FYM in the ratio of 2 : 1. The FYM is also crushed to ensure homogenous mixture. The mixture should be free from stone or any other foreign objects.

f. Preparation of seedling bed:

Biodegradable sheets (130 cm × 1650 cm) are placed on the selected plot of land. The

frames are placed over the polythene sheet such that clear width remains 100 cm. Pulverized soil-FYM mixture is used to fill up the frame over the sheet to have a bed dimension 100 cm × 1600 cm × 1.5 cm. Wooden mallet may be used to level as well as to provide mild compaction to the soil-FYM mixture.

g. Sowing of sprouted seeds:

Sprouted seeds are uniformly sown in the soil bed at the rate of about 1 kg/sq. mtr. Beds are sprinkled with water after sowing.

h. Water management:

Beds are covered with light jute bag or straw and water should be sprinkled on the bed for 4 days under covered condition so that soil never dries. The covers are removed after four days. The sprinkling of water may need to be continued up to one week. After about one week seedling would attain some height and water may be applied by flooding. The depth of water should be half of the seedling height.

i. Uprooting of seedlings:

Seedlings become ready for transplanting when its height becomes 15 cm with 3 to 4 leaves. The seedling mats are then cut into pieces to be used for transplanter.

Field preparation:

Field should be prepared thoroughly by ploughing 4 to 5 times followed by harrowing and laddering. Ploughing should be started at least 21 days ahead of transplanting so that weeds are dried up/decayed.

Land preparation by bullock drawn modified helical blade puddler:

Modified helical blade puddler is an improved bullock drawn implement of puddling operation. The weight of the implement is about 26 kg and it covers about 50 cm in one pass. It can be operated by all types of bullocks available in Assam. One or two passes of puddler operation followed by one pass of mould board plough are sufficient for obtaining good quality puddle soil. The puddler can cover 2 to 2.5 bigha of land per day.

Considerations for efficient use of the modified helical blade puddler:

The well ploughed field should be covered with water at the time of puddler operation. To protect the sharpness of the blade the implement should never be operated over stones or hard ground. At the end of its operation the puddler should be properly cleaned and stored dry. Painting is advisable to avoid rusting.

Organic Nutrient package for Rice

a) Manures and Fertilizers:

Several options of organic nutrients are available depending on the availability at different locations.

i) Enriched Compost (@ 5 t/ha) + Biofertilizer (*Azospirillum*, PSB and KSB mix @ 4.0

kg/ha as seedling root dip).

ii) Fresh Azolla @ 400-450 kg/ha as dual crop + Biofertilizers (*Azospirillum*, PSB and KSB mix @ 4.0 kg/ha as seedling root dip**)**

Application of biofertizers Seedling root dip treatment:

A bed of size (2.5 m x 2.5 m x 0.15 m) is prepared in the field filled with up to 2 inches of water to which 4.0 kg of *Azospirillum,* PSB and KSB mix (rice seedlings for 1 ha) is suspended and a slurry is prepared. The roots of the rice seedlings are dipped for 8 to12 hours (overnight) and then transplanted to the main field.

Application of Azolla in rice:

Azolla is a free-floating water fern which lives in symbiotic association with a N- fixing blue green algae (*Anabaena azollae*) and has potential of providing 30-60 kg N/ha under normal field conditions.

Growing Azolla in a separate plot:

Azolla is propagated in pits near the main field to produce enough to inoculate one hectare of rice land.

Dual culture of Azolla with rice:

Fresh Azolla @ 60-70 kg/bigha is applied one week after rice transplantation. After 3-4 weeks of growth and formation of mat, the Azolla is incorporated in the soil. Again after 7-8 week, the Azolla will cover the field and need second incorporation. With these two incorporations, 2-3 t of Azolla can be supplied in each bigha of rice field with a supplementation of 4-8 kg of Nitrogen per crop per season.

Green manuring

Green manuring is considered to be basic component of organic farming wherein un-decomposed green material is ploughed or turned down in soil. Generally, legumes are grown under this practice but under certain conditions non-legume crops are used.

1. Green manuring *in-situ*:

In this system, green manure crops are grown and buried in the same field. The most common green manure crops grown under this system are sannhemp (*Crotalaria juncea*), dhaincha (*Sesbania aculeata*) and guar (*Cyamopsis tetragonoloba*). The manure, being a bulky one, is usually applied as basal dressing before the main crop is raised in the field. However, when the green manure crops are grown and incorporated in the same field, the best stage of incorporation is the flowering stage of the crop. Therefore, the seeds of green manuring crops @ 5 kg/ha are sown 60 days prior transplanting of rice and incorporated after about 40 to 45 days growth. After incorporation, 15 to 20 days is allowed for decomposition to take place and only after this, the rice seedlings are transplanted to the main field.

2. Green leaf manuring :

In the case of green leaf manuring, the green leaves and tender green twigs collected from shrubs and trees grown on bunds, wastelands and nearby forest areas are spread over the field 15-20 days prior to transplanting of rice and incorporated in the field by the use of implements or by human labour. However, when green-leaf manuring is practiced by bringing in the green plants grown elsewhere, no definite stage can be fixed as the green leaf manuring is controlled by many other factors. The common shrubs and trees used are Gliricidia (*Gliricidia maculata*), Sesbania (*Sesbania speciosa*), karanj (*Pongamia pinnata*), Subabul (*Leucaena leucocephala*) etc.

Age of seedlings and spacing for Normal *sali*

Varieties	Age of seedlings (days)	Spacing (cm)
1. Short and medium duration varieties (up to 120 days duration)	25	20 × 15
2. Medium long duration varieties (beyond 120-130 days)	30-35	20 × 15
3. Long duration varieties (beyond 130 days)	30-40	20 × 20

Number of Seedlings per Hill:

i) 2-3 seedlings for normal planting (July – August)

ii) 4-6 seedlings for late planting (September).

Depth of Planting:

4-5 cm depth of planting should be maintained for all varieties.

Interculture:

Two weeding should be given with paddy weeder or hoe at 20 and 40 days after transplanting.

Water Management:

In s*ali* rice, application of 5 cm irrigation water 3 days after disappearance of ponding water is recommended in medium and heavy soils.

Plant Protection Measures in the Field:

A. Diseases:

I. Blast:

a. Grow tolerant varieties.

b. Treat the seed as explained under seed treatment.

II. Bacterial leaf blight:

a. Grow tolerant varieties, *viz*. Lakhimi and Mahsuri.

b. Four sprays of biopesticides like Biotime (mixture of *P. fluorescens, T. viride* and *M. anisopliae*) @ 2 ml/ m^2 can effectively reduce stem borer incidence both in vegetative and reproductive stage. Four (4) spray of Biogreen @ 2 ml/m^2 is effective against management of BLB of rice.

Sheath blight:

a. Spraying of two commercial plant derived Cymbopogon products @ 5 ml/*l* and Neem based fungicide @ 3 ml/*l* is recommended for management of sheath blight disease of rice. The first spraying should be given as soon as symptoms of the disease are observed in the field followed by a second spraying at 10-12 days interval.

B. Insect Pest

a) 8 releases of *Trichogramma japonicum* @ 50,000/ha/week starting from 30 days after transplanting or appearance of moth captured by pheromone trap (@ 24 nos. per ha) gives significantly good control (30-60% parasitization) of rice stem borer and leaf folder. Since *Trichogramma* is an egg parasitoid, its releases should be coincided with the egg laying activity of the pest. Timely releases are crucial. Releases should be made over the entire infested area throughout the egg laying period of the pests, which results in uniform and effective control.

Method of application: Each 'Trichocard' is to be cut in to 10 pieces and distributed randomly over the entire field by fixing them to the plants by using a stapler or adhesive.

b) Apply neem oil 1500 ppm @ 3-5 ml /*l* as an alternative to chemical insecticides

c) To control rice pests, erect 50 'T'-perches per ha 2 ft (60 cm) above crop canopy as roosting site for insectivorous birds, which are to be removed before flowering in order to prevent activity of granivorous bird.

d). Installation of artificial Barn Owl Nest Box on tree trunk at a height of 10-15 feet near to agricultural land during October for conservation and propagation of Barn owl to control rodents in crop field and godown.

e). Apply compost @ 1 ton/ha along with *Azospirillum* and *PSB* as root-dip treatment in rice

C). Root-knot nematode: Apply *Pseudomonus flourescens* @ 20 g/ sq. m at the time of sowing

Apply *Bacillus subtilis* ($1x10^8$ cfu/g) @ 10 kg/ha before sowing to control rice root knot nematode (*Meloidogyne graminicola*). The bioagent should be enriched in well decomposed FYM (10 kg in 200 kg FYM) before application.

RICE BASED CROPPING SYSTEM FOR ORGANIC PRODUCTION IN ASSAM

Following cropping systems are suggested for Organic Production in Assam under medium land situation:

1. **Winter rice-potato-lady's finger sequence**
2. **Winter rice-toria-black gram sequence**

DETAILS OF THE CROPPING SYSTEM

1.2.1 WINTER RICE-POTATO-LADY'S FINGER SEQUENCE

Particulars	**Kharif**	**Rabi**	**Summer**
Crop	Rice	Potato + French bean	Lady's finger + Green gram
Fortnight of sowing/ planting	2nd fortnight of June	1st fortnight of November	2nd fortnight of March
Fortnight of harvesting	2nd fortnight of October	1stfortnight of March	1st fortnight of June
Varieties suitable for organic farming	Keteki Joha	Kufri Megha (P) + Contender (FB)	Parbhani Kranti (LF) + Pratap (GG)

CROP (*KHARIF*): RICE

Importance features of suitable for the varieties

Parameters for cv. KetekiJoha	
Duration (days)	155
Average yield under organic production (kg/ha)	3220
Sources of availability	RARS, AAU, Titabar
Suitable regions/ Zones/ Districts in the state	UBVZ, CBVZ, NBPZ, BVZ

Specific resistance/ tolerance to pests	-
Specific resistance/ tolerance to disease	-

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

Cultural practices:

Seed rate (kg/ha)	45		
Pre-sowing/ planting treatment of seeds/ seedlings	**Material used**	**Recommended rate**	**Method of application**
	Biofertilizers *i.e. Azospirillum*, PSB & KSB	3.5 kg each /ha	Root-dip treatment
Spacing (Row × plant) in cm	20 × 20		
Basal application of organic sources of nutrients	**Sources**	**Quantity / ha**	
	Compost	4.44 ton (fresh wt. basis)	2.96 ton (dry wt. basis)
	Seed rate (kg/ha)	25 kg/ha (black gram); 21 q/ha (lady's finger)	
	Pre-sowing/ planting treatment of seeds/ seedlings	Material used	
Major weeds		Biofertilizers *i.e. Rhizobium* &PSB (for blackgram)	
Weed management	**Critical stages of weeding**	Recommended practice for organic production	
	20-30 days after transplanting	Mechanical weeding by Japanese Paddy Weeder	
Organic plant protection measures	Name of the pests/ diseases	Organic materials recommended for control	Quantity required (kg/ha or *l*/ha)

	Insects like caseworm, stem borer, leaf folder, plant hopper	Mixture of cow urine and neem leaf extract	1 liter/ 250 liter of water/ha
		Pumello fruit (after making pieces)	30 kg/ha

CROP (*RABI*) : POTATO + FRENCH BEAN

Importance features of suitable for the varieties

Parameters for cv. Kufri Megha + cv. Contender	
Duration (days)	Potato:120; French bean: 100
Average yield under organic production (kg/ha)	6190 (potato yield) &4000 (French bean yield)
Sources of availability	Certified seeds of the recommended varieties are available in Govt. agencies or other recognized agencies.
Suitable regions/ Zones/ Districts in the state	UBVZ, CBVZ, NBPZ, BVZ
Specific resistance/ tolerance to pests	French bean cv. Contender is resistant to most of the major insect-pests.
Specific resistance/ tolerance to disease	Kufri Megha is late blight resistant cultivar.

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

Cultural practice

Seed rate (kg/ha)	22.5 q/ha (potato); 50 kg/ha (French bean)		
Pre-sowing/ planting treatment of seeds/	**Material used**	**Recommended rate**	**Method of application**
	Biofor Pf (for potato)	500g/ q	Seed treatment

seedlings	Biofertilizers *i.e. Azotobacter* &PSB (for potato)	5 kg/ha	Seed treatment
	Biofertilizers *i.e. Rhizobium* & PSB (for French bean)	500 g each / 10 kg seed	Seed treatment
Spacing (Row × plant) in cm	For potato:50 × 15 For French bean: 45 × 30		
Basal application of organic sources of nutrients	**Sources**	**Quantity / ha**	
	Compost	3.33 ton for potato + 1.67 ton for French bean (fresh wt. basis)	2.22 ton for potato + 1.11 ton for French bean (dry wt. basis)
	Vermicompost	1.63 ton for potato + 0.82 ton for French bean (fresh wt. basis)	1.36 ton for potato + 0.68 ton for French bean (dry wt. basis)
	Mustard oilcake	0.49 ton for potato + 0.24 ton for French bean (fresh wt. basis)	0.44 ton for potato + 0.22 ton for French bean (dry wt. basis)
Major weeds	*Chenopodium album, Amaranthus, Cyperus rotundas etc.*		
Weed management	**Critical stages of weeding**	**Recommended practice for organic production**	
	20-25& 50-55 DAS	Manual weeding by hand & using hoe	
Organic plant protection measures	Name of the pests/ diseases	Organic materials recommended for control	Quantity required (kg/ha or *l*/ha)
	Late blight of potato	Copper oxychloride	Eight sprays of 0.2% copper oxychloride at 5 days interval starting from 40 days after planting
Other operations	Earthing up in case of potato at 25 & 60 DAS		

CROP (*SUMMER*): LADY'S FINGER + GREEN GRAM

Importance features of the varieties

Parameters for Lady's finger (cv. Parbhani Kranti) + Green gram (cv. Pratap)	
Duration (days)	Lady's finger:120; Green gram: 65-70
Average yield under organic production (kg/ha)	980 (lady's finger yield) &300 (green gram yield)
Sources of availability	Certified seeds of the recommended varieties are available in Govt. or other recognized agencies.
Suitable regions/ Zones/ Districts in the state	UBVZ, CBVZ, NBPZ, BVZ
Specific resistance/ tolerance to pests	-
Specific resistance/ tolerance to disease	Lady's finger cv. Parbhani Kranti resistant to yellow vein mosaic virus (YMV). Green gram cv. Pratap is resistant to *Cercospora* leaf spot and tolerant to YMV.

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

Cultural practices:

Seed rate (kg/ha)	21 q/ha (lady's finger); 18 kg/ha (green gram)		
Pre-sowing/ planting treatment of seeds/ seedlings	**Material used**	**Recommended rate**	**Method of application**
	Biofertilizers *i.e. Azotobacter* &PSB (for lady's finger)	500 g each / 10 kg seed	Seed treatment
	Biofertilizers *i.e. Rhizobium* & PSB (for green gram)	500 g each / 10 kg seed	Seed treatment
Spacing (Row × plant) in cm	For lady's finger: 30 × 15 For green gram: 30 × 10		

Basal application of organic sources of nutrients	**Sources**	**Quantity / ha**	
	Compost	2.78 ton for lady's finger + 0.83 ton for green gram (fresh wt. basis)	1.85 ton for lady's finger + 0.56 ton for green gram (dry wt. basis)
	Vermicompost	1.36 ton for lady's finger + 0.27 ton for green gram (fresh wt. basis)	1.13 ton for lady's finger + 0.23 ton for green gram (dry wt. basis)
	Mustard oilcake	0.41 ton for lady's finger + 0.08 ton for green gram (fresh wt. basis)	0.37 ton for lady's finger + 0.07 ton for green gram (dry wt. basis)
Major weeds	*Amaranthus, Pleibium*sp., *Hydrolia*sp., *Azaratum*sp.,		
Weed management	Critical stages of weeding	Recommended practice for organic production	
	20-25 & 50-55 DAS	Manual weeding by hand & using hoe	

1.2.2. WINTER RICE-TORIA-BLACKGRAM SEQUENCE

Particulars	***Kharif***	***Rabi***	***Summer***
Crop	Rice	Toria+ Lady's finger	Black gram + French bean
Fortnight of sowing/ planting	2nd fortnight of June	2nd fortnight of October	1st fortnight of March
Fortnight of harvesting	1st fortnight of October	2ndfortnight of February	1st fortnight of June
Varieties suitable for organic farming	Rajendra Suwasini	TS-67 + Parbhani Kranti	PU-31 + Contender

CROP (*KHARIF*): RICE

Importance features of the varieties

Parameters for cv. Rajendra Suwasini	
Duration (days)	130
Average yield under organic production (kg/ha)	3380
Sources of availability	Integrated Farming System, AAU, Jorhat
Suitable regions/ Zones/ Districts in the state	UBVZ, CBVZ, NBPZ, LBVZ, BVZ
Specific resistance/ tolerance to pests	*Rajendra Suwasini* is resistant to Gandhi bug
Specific resistance/ tolerance to disease	*Rajendra Suwasini* is resistant to Sheath blight and BLB

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

Cultural practices:

Seed rate (kg/ha)	45		
Pre-sowing/ planting treatment of seeds/ seedlings	**Material used**	**Recommended rate**	**Method of application**
	Biofertilizers *i.e. Azospirillum*, PSB & KSB	3.5 kg each /ha	Root-dip treatment
Spacing (Row × plant) in cm	20 × 15		
Basal application of organic sources of nutrients	Sources	Quantity / ha	
	Compost	4.44 ton (fresh wt. basis)	2.96 ton (dry wt. basis)
	Vermicompost	2.18 ton (fresh wt. basis)	1.81 ton (dry wt. basis)
	Mustard oilcake	0.65 ton (fresh wt. basis)	0.59 ton (dry wt. basis)

Major weeds	*Echinocloa crassgali, Echinocloa colona, Cyperrus* spp., *Eleusine indica, Digiteria* spp., *Limnophyla munnularia*, *Luduigia* spp., *Fisindocarpa linifolia*		
Weed management	Critical stages of weeding	Recommended practice for organic production	
	20-30 days after transplanting	Mechanical weeding by Japanese Paddy Weeder	
Organic plant protection measures	**Name of the pests/ diseases**	**Organic materials recommended for control**	**Quantity required (kg/ha or *l*/ha)**
	Insects like caseworm, stem borer, leaf folder, plant hopper	20 kg neem leaf extract to be mixed with10 liters of cow urine with 5 kg fresh cowdung. Keep the mixture for 48 hours for incubation, squeeze it and filter it.	10 liters/ 250 liters of water/ha
		Pumello fruit (after making pieces)	30 kg/ha
	Disease management	Soil Treatment with Biogreen (*T. viride based Biopesticide* - Plant Growth Promoting Microbe (PGPM) and entomopathogens *viz. Bacillus thuringiensis, M. anisopliae, B. bassiana, V. lecanii)* @ 2.5 kg/ha (incubation 1:50)+ Seed Treatment with Biogreen @ 5% + Foliar Spray with Biogreen @ 5% at 45 DAS	
Parameters for cv. TS-67 + cv. HUW-234			
Duration (days)		Toria:85-90; Wheat:110	
Average yield under organic production (kg/ha)		440 (toria yield) &1200 (wheat yield)	

Sources of availability	Certified seeds of the recommended varieties are available in Govt. agencies or other recognized agencies.
Suitable regions/ Zones/ Districts in the state	UBVZ, CBVZ, NBPZ, BVZ
Specific resistance/ tolerance to pests	-
Specific resistance/ tolerance to disease	-

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

Cultural practices:

Seed rate (kg/ha)	8 kg/ha (toria); 100 q/ha (wheat)		
Pre-sowing/ planting treatment of seeds/ seedlings	**Material used**	**Recommended rate**	**Method of application**
	Biofertilizers *i.e. Azotobacter* & PSB (for toria)	500 g each / 10 kg seed	Seed treatment
Spacing (Row × plant) in cm	For toria: 30 × 10 For wheat: 30 × 10		
Basal application of organic sources of nutrients	**Sources**	**Quantity / ha**	
	Compost	3.33 ton for toria + 4.43 ton for wheat(fresh wt. basis)	2.22 ton for toria + 2.96 ton for wheat(dry wt. basis)
	Vermicompost	1.63 ton for toria + 2.18 ton for wheat(fresh wt. basis)	1.36 ton for toria + 1.81 ton for wheat(dry wt. basis)

	Mustard oilcake	0.49 ton for potato + 0.65 ton for wheat(fresh wt. basis)	0.44 ton for potato + 0.59 ton for wheat(dry wt. basis)
Major weeds	*Chenopodium album, Amaranthus, Cyperus rotundas etc.*		
Weed management	Critical stages of weeding	Recommended practice for organic production	
	20-25& 50-55 DAS	Manual weeding by hand & using hoe	

Yield : Toria - 4-5 q/ha, Wheat-12-13 q/ha

CROP (*SUMMER*): BLACK GRAM + LADY'S FINGER

Importance features of suitable for the varieties

Parameters for cv. TS-67 + cv. Pravani Kranti	
Duration (days)	Toria: 65-70; Lady's finger:120
Average yield under organic production (kg/ha)	500 (black gram yield) &2580 (lady's finger yield)
Sources of availability	Certified seeds of the recommended varieties are available in Govt. agencies or other recognized agencies.
Suitable regions/ Zones/ Districts in the state	UBVZ, CBVZ, NBPZ, BVZ
Specific resistance/ tolerance to pests	-
Specific resistance/ tolerance to disease	Lady's finger cv. Parbhani Kranti resistant to yellow vein mosaic virus (YMV).

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

Cultural practices:

Seed rate (kg/ha)	25 kg/ha (blackgram); 21 q/ha (lady's finger)

Pre-sowing/ planting treatment of seeds/ seedlings	**Material used**	**Recommended rate**	**Method of application**
	Biofertilizers *i.e. Rhizobium* &PSB (for black gram)	500 g each / 10 kg seed	Seed treatment
	Biofertilizers *i.e. Azotobacter* &PSB (for lady's finger)	500 g each / 10 kg seed	Seed treatment
Spacing (Row × plant) in cm	For black gram: 30 × 10 For lady's finger: 30 × 15		
Basal application of organic sources of nutrients	**Sources**	**Quantity / ha**	
	Compost	0.83 ton for black gram + 2.78 ton for lady's finger (fresh wt. basis)	0.56 ton for black gram + 1.85 ton for lady's finger (dry wt. basis)
	Vermicompost	0.27 ton for black gram + 1.36 ton for lady's finger (fresh wt. basis)	0.23 ton for black gram + 1.13 ton for lady's finger (dry wt. basis)
	Mustard oilcake	0.08 ton for black gram + 0.41 ton for lady's finger (fresh wt. basis)	0.07 ton for black gram + 0.37 ton for lady's finger (dry wt. basis)
Major weeds	*Chenopodium album, Amaranthus, Cyperus rotundas etc.*		
Weed management	Critical stages of weeding	Recommended practice for organic production	
	20-25 & 50-55 DAS	Manual weeding by hand & using hoe	

Yield: Black gram - 5-6 q/ha
Lady's Finger - 25-27 q/ha

OILSEED CROPS

Rapeseed (*Brassica rapa* var. toria*)*

Variety	Year of notification	Average yield (q/ha)	Days to maturity	Reaction to major diseases
AAU TS 38	2021	10-12	90-95	-
TS 36	-	10-12	90-95	-
JT 90-1 (Jeuti)	2020	6.97	89	Moderately Susceptible to *Alternaria* blight (leaves and pods show symptoms); moderately susceptible in case of incidence of aphids and sawfly

Soil Type : Sandy loam soils are preferable.

Time of sowing : Mid-October to mid-November.
Early sowing helps in escaping attack of aphids.

Field Preparation : The land should be ploughed 4-6 times followed by laddering to obtain fine tilth.

Seed rate : 7.5 kg/ha (1kg/bigha)

Interculture: If necessary, thinning and weeding should be completed within 15 to 20 DAS.

Irrigation

If necessary, one irrigation of 6 cm depth of water may be applied either at 50% flowering or at early siliqua formation stage. Source of irrigation water should be on-farm rain water harvesting tank/pond.

Nutrient management:

- Seed inoculation: The seed should be moistened with clean water with care so as to avoid excessive wetting. *Azotobacter* and Phosphate solubilizing bacteria (PSB) should be mixed with @ 50 g each /kg seed. The inoculated seeds should not be exposed to the sun.
- Apply Vermicompost @ 1 t/ha (133 kg/bigha), rock phosphate @ 30 kg/ha (4 kg/bigha) and Borax @ 7.5 kg/ha (1 kg/bigha) at the time of land preparation.

Plant Protection:

A. Disease:

i) *Alternaria* leaf and pod blight (*Alternaria* spp.)

- Treat the seeds with *Trichoderma viride* based biopesticide (Biogreen-5) @ 10 g/kg seed.
- Spray *Bacillus* formulation @ 5 ml/l (3.0 *l*/ha in 600 liters of water; 400 ml/bigha in 80 liters of water) twice, starting from the appearance of disease at an interval of 15 days.

B) **Insect-pest:**

i) Aphid

- Need based foliar spray of Neem Seed and Kernel Extract (NSKE) @ 5%
- Installation of bird perch @ 40 nos./ha (5-6 nos./bigha)

Harvesting:

The crop gets ready for harvest when 75-80% siliquae turn yellow.

Summer & *Kharif* Sesame

Variety	Year of Notification	Average Yield (q/ha)	Days to maturity
AAU SHL TIL1 (Champawati)	2022	8 - 9	80

Soil Type: Well drained loamy soils are preferable

Time of sowing: First week of March to first week of April (Summer) June to mid-August (Kharif).

Field Preparation: Land should be prepared to a fine tilth by 3-4 ploughings followed by laddering

Seed rate: 4 kg/ha (530 g/bigha)

Spacing: 30 cm between rows and 15 cm between plants

Intercultural operation: One weeding should be done at 20 days after sowing

Integrated nutrient management:

Inoculate the seeds with *Azotobacter* and PSB each @ 50 g/kg of seeds. Vermicompost @ 1 ton/ha (133 kg/bigha) and rock phosphate @ 30 kg/ha (4 kg/bigha) should be applied at the time of land preparation.

Plant protection

Disease management:

***Phytophthora* blight (*Phytophthora nicotianae var. parasitica f.sp. sesami*)**: Treat the seeds with *Trichoderma viride* based biopesticide @ 10 g/kg seed.

Spray *Bacillus* formulation @ 5 ml/*l* (3.0 l/ha in 600 liters of water; 400 ml/bigha in 80 liters of water) twice, starting from the appearance of disease, at an interval of 10 days.

Insect-pest management

Bihar hairy caterpillar and Leaf webber

Need based foliar spray of Neem Seed Kernel Extract (NSKE) @ 5%. installation of bird perch @ 40 Nos./ha (5-6 Nos./bigha)

Harvesting:

The crop should be harvested when the leaves and stems turn yellow and defoliation starts, or one or two capsules at the bottom start cracking from the tip.

PULSES CROPS

Kharif Blackgram & Greengram

Crop	Variety	Year of Notification	Average Yield (q/ha)	Days to maturity
Blackgram	SBC 40 (Shyamal)	2022	10-11	75-85
Greengram	SGC 16 (Rupohi)	2022	10-11	65-68

Soil Type: Well drained loamy soils are preferable

Time of sowing: Mid-August to mid-September

Field Preparation: The land is to be ploughed 2-3 times followed by levelling

Seed rate: 22.5 kg/ha or 3 kg/bigha (Black gram)

20 kg/ha or 2.75 kg /bigha (Green gram)

Spacing: 30 cm between rows and 10 cm between plants

Intercultural Operation: One weeding at 20-25 days after sowing is to be done

Nutrient management:

- Inoculate the seeds with *Rhizobium* and PSB each @ 50g/ kg seeds.
- Apply Vermicompost @ 1t/ha (133 kg/bigha) and rock phosphate @ 30 kg/ha (4 kg/bigha) at the time of land preparation.

Plant Protection

A. Diseases

Leaf spot (*Cercospora* spp.), Powdery mildew (*Erysiphe polygoni*) & Web blight (*Rhizoctonia solani*)

- Treat the seeds with *Trichoderma viride* based biopesticide @ 10 g/kg seed.
- Spray *Bacillus* formulation @ 5 ml/l (3.0 l/ha in 600 liters of water; 400 ml/bigha in 80 liters of water) thrice, starting from appearance of disease, at an interval of 10 days.

B. Insect-pests

i) Aphid and Pod borer

- Need based foliar spray of NSKE @ 5%
- Installation of bird perch @ 40 nos./ha (5-6 nos./bigha)
- Installation of yellow sticky trap (0.3m x 0.2m) @ 20 Nos. /ha (2-3 nos./bigha)

Harvesting:

Harvesting is to be started when 75% of the pods mature and become darkish in colour

Lentil (*Lens culinaris*)

Varieties:

Variety	Year of notification	Average yield (q/ha	Days to maturity	Reaction to major diseases
Pant lentil 9 (Small seeded)	2016	13-14	113-135	Resistant to rust, wilt and Ascochyta blight
IPL 220 (Small seeded)	2018	14-18	119-122	Resistant to rust & Fusarium wilt
HUL 57 (Small Seeded Lent)	2005	12-14	112-115	Resistant to rust & tolerant to wilt
Axom Masur 1 (SL 2-24)	-	12-14	115-120	Moderately resistant to wilt
Axom Masur 2 (SL 2-28)	-	12-14	112-120	Moderately resistant to wilt

Soil type **:** Sandy loam to loamy soil is preferable

Time of sowing : Mid-October to mid-November

Field preparation: The land should be ploughed 3-4 times to obtain good tilth.

Seed rate **:** 30 kg/ha (4 kg/bigha)

Spacing **:** The seeds are to be sown in lines at a spacing of 25 cm between rows.

Weed management: One weeding at 20-25 days after sowing is to be done.

Nutrient management:

- Seed inoculation: The seed should be moistened with clean water with care so as to avoid excessive wetting. *Rhizobium* and Phosphate solubilizing bacteria (PSB) should be mixed with @ 50 g each /kg seed. The inoculated seeds should not be exposed to the sun.
- Apply Vermicompost @ 1t/ha (133 kg/ bigha) and rock phosphate @ 30kg/ha (4 kg/bigha) at the time of land preparation.

Plant Protection:

A. Diseases

i. Fusarium wilt (*Fusarium oxysporum* f.sp. lentis)

- Use of resistant variety *viz.,* Plant Lentil 9, IPL 220, etc.
- Treat the seeds with *Trichoderma viride* based biopesticide @ 10 g/kg seed.

B. Insect-pests

i) Aphid

- Need based foliar spray of NSKE @ 5%
- Installation of bird perch @ 40 Nos./ha (5-6 nos./bigha)

Harvesting: Harvesting should be done when about 80% of the pods turn yellow.

HORTICULTURAL CROPS

I. VEGETABLE CROPS

1.1.1. Okra (*Abelmoschus esculentus*)

a) **Variety**: Arka Anamika, Pusa Sawani, Parbhdani Kranti

b) **Sowing time**: May-July (for rainy season crop)

c) **Spacing**: 50 cm X 45 cm

d) **Seed rate**: 8 kg/ha

Soil selection and land Preparation:

Well drained sandy loam to clay loam soil is suitable for okra cultivation. Before liming @ 10-12 q/ha should be done to raise soil pH depending upon the soil test result and mixed with the soil at least one month before sowing of seeds.

Application of manures and biofertilizers:

Rock phosphate @ 313 kg/ha and FYM @ 5 t/ha + Vermicompost @ 1 t/ha should be applied before sowing of seeds.

Seed treatment:

Pre-soaking of seeds in water for 24 hrs enhances germination. Floater seeds should be removed and seeds are treated with a mixture of Azotobacter and PSB @ 7.5 g each with 100 g of seeds.

Plant protection techniques:

i) Use of resistant varieties against yellow vein mosaic virus. Destruction of crop residues after harvest and phyto-sanitation measures is to be adopted.

ii) **Use of pheromone traps**: Pheromone traps with lures are commercially available for pests like *Helicoverpa armigera* (Helilure), *Spodoptera litura* (Spodolure) and *E. earias*(Earias lure). Install 5 traps/ha with lures for each pest, keep the distance of 1200 square meters between the traps. Trap should be installed in the field in such a way that the position of lure is always 6" above the crop canopy. Replace the lures once in 25-30 days depending upon the weather conditions. The trapped moths should be collected and destroyed regularly. ETL for *H. armigera* is 8 to 10 moths per day per trap.

iii) **Use of yellow sticky traps**: Yellow sticky traps should be set up for monitoring whitefly, thrips, etc. @ 10 traps/ha. Locally available empty tins can be painted with yellow colour and coated with castor oil/ grease on outer surface may also be used as

yellow sticky traps. However, yellow cart paper can be cut into the A4 size paper and smeared it with 5 ml mustard oil also a good alternative of costly YST.

iv) 6 releases of *T. chilonis* or *T. priteosum* @ 1,00,000/ha against *H. armigera* at weekly interval

v) Need based application of neem oil 500 ppm @ 5 ml/*l* as an alternative to chemical insecticides at an interval of 15 days.

vi) Seed treatment with Org-Pochojal (a liquid bioformulation of *Pochonia chlamydosporia*, AAU product) @ 5 ml/*l* along with application of Org-Pochojal enriched compost @ 2 t/ha (Mix 40 ml Org-Pochojal/kg of compost, incubate for one week and then the compost should be mixed with 10 kg of compost. Repeat the incubation for one week and mix the 10 kg of compost with 100 kg of compost and apply in the field) to reduce the infestation of root knot nematode. Seed treatment with *Bacillus megaterium* @ 5 ml/*l* + soil application of 2 ton of vermicompost enriched with 5 liters of *B. megatorium*/ha also reduces the infestation of root knot nematode.

Interculture:

i) Use of black mulch (25 micron) between the rows control weeds and also conserves soil moisture.

ii) Crops should be maintained weed free for 4-6 weeks after sowing by hoeing/ hand weeding.

Harvesting: After 45-50 days of sowing first picking can be done. Fruit should be picked every alternate day to get maximum yield.

Yield: 11-12 t/ha

1.1.2. Cabbage (*Brassica oleracea L.*)

a) Variety:

Early maturity: Golden Acre, Pride of India, Pusa Mukta (Sel-8)

Late maturity: Drum Head and Eclipse Drum Head.

b) Sowing time: Sep- Nov

c) Planting time : Oct-Nov

d) Spacing: Early maturity : 45 x 45 cm Late maturity: 60 x 60 cm

e) Seed rate: 800 g/ha for early; 450 g/ha for late, 10 g of seed should be sown/m^2

Seedbed preparation, seedling raising and transplanting:

Selected land for seedbed preparation should be solarized with thin transparent

polythene sheet (100 gauge) for one month before sowing of seed. Before covering the bed with polythene sheet dried well rotten cowdung and sand (in case of clay soil) @ 40 kg each per $5m^2$ should be mixed. Bed should be moistened before covering and sides of the polythene sheet should be properly covered with soil to restrict the entry of air.

Before seed sowing, seed bed should be mixed thoroughly with 250 g neem cake powder, 50 g *Trichoderma viride* and 25 g *Pseudomonas fluorescens*. Seeds treated with *Pseudomonas fluorescens* powder @ 5 g with 100 g of seed along with little amount of water followed by shade drying. After seed sowing, the seedbed should be watered lightly and then seeds should be covered with a mixture of dried sieved cow dung and *Trichoderma viridi* (Mixture 10 g of *Trichoderma* powder with 1 kg of cow dung powder). This will reduce the soil borne plant pathogen.

Before sowing of seeds the seed bed should be mixed thoroughly with 250 g neem cake powder, 50 g *Trichoderma viride* and 25 g *Pseudomonas fluorescens*.

Any neem-based insecticides (2 ml/ *l*) is to be sprayed to the young seedlings whenever necessary.

Seedlings are to be transplanted to the main field after 25-30 days of sowing. Before transplanting seedling, roots are dipped in a slurry of Azotobacter (AZB) and Phosphorus Solubilizing Bacteria (PSB) mixture for 30 minutes (Slurry is prepared by mixing 75 g AZB and 75 g PSB for 1000 Nos. of seedlings.

Soil selection and land Preparation:

Deep summer ploughing is advisable. Well drained sandy loam to clay loam soil is suitable for cabbage cultivation. Before transplanting of seedlings, the land has to be ploughed and seeds of green manuring crops like Dhaincha or Sunhemp are sown in the month of May. After one and half month or two months of sowing young green manure plants are cut and incorporated with the soil by ploughing. Liming @ 10-12 q/ha should be done to raise soil pH depending upon the soil test result and mixed with the soil at least one month before transplanting of seedlings.

Application of manure and biofertilizers:

Rock phosphate @ 375 kg/ha and Vermicompost @ 5 t/ha should be applied before transplanting of seedlings.

Plant protection techniques:

a) Follow crop rotation with non-cruciferous crops.

b) Deep summer ploughing helps in exposing resting stages of pests to predators and sunlight.

c) Use of resistant varieties against black rot. Destruction of crop residues after harvest and phytosanitation measures is to be adopted.

d) **Use of pheromone traps:** Pheromone traps with lures are commercially available for pests like DBM, *Plutella xylostella*; Cabbage butterfly, *Pieris* spp.; *Helicoverpa armigera* (Helilure); *Spodoptera litura* (Spodolure)etc. Install 8 traps/ha with lures for each pest, keep the distance of 1200 square meters between the traps. Trap should be installed in the field in such a way that the position of lure is always 6" above the crop canopy. Replace the lures once in 25-30 days depending upon the weather conditions. The trapped moths should be collected and destroyed regularly. ETL for *H. armigera* is 8 to 10 moths per day per trap.

e) **Use of yellow sticky traps:** Yellow sticky traps should be set up for monitoring whitefly, thrips etc. @ 20-25 traps/ha. Locally available empty tins can be painted with yellow colour and coated with castor oil/ grease on outer surface may also be used as yellow sticky traps. However, yellow chart paper can be cut into the A4 size sheets and smeared it with 5 ml of mustard oil also a good alternative of costly YST.

f) Six releases of *T. chilonis, T. priteosum* @ 1,00,000/ha with weekly intervals helps in controlling DBM and other lepidopteran pests .

g) Need based application of neem oil 500 ppm @ 5 ml/*l* as an alternative to chemical insecticides at an interval of 15 days.

h) Treat the seeds with *Trichoderma harzianum* based bioformulation like Org-Trichojal @ 5 g/liter of water + CMC @ 0.02% for 1 hr followed by shade dry for 2 hrs prior to sowing can reduce the soil borne disease like damping off.

i) **Use of trap crop**: Two rows are to be sown with mustard as trap crop at the beginning and after 25 cabbage rows. Bold seeded mustard is more suited. Mustard is to be sown twice; first is at 15 days prior to cabbage transplanting, while the second one is at 25 days after transplanting. Thick showing of mustard i.e. 50-60 plants/m rows is recommended usually, the intercropped cabbage is free from infection during early stages. However, there may be some incidence at later stages. For this apply 5% NSKE.

j) Erect bird perches at least @ 15 nos./ha to provide roosting sites for predatory birds to consume insect larvae.

Interculture:

Irrigation:

The first irrigation is to be given immediately after transplanting and continued till the seedlings are established and subsequent irrigations should be given whenever required.

Availability of water in soil should be as far as practicable uniform, otherwise splitting may occur.

Use of black mulch (50 micron) between the rows control weeds and also conserves soil moisture or weeding should be done at 20 and at 40 days after transplanting. Earthing up can be done in about 30 days after planting.

Harvesting:

Heads are ready to harvest at about 60- 100 days after transplanting depending upon the variety.

Yield:

Depending on variety, spacing and management practices the yield may vary from 180-200 q/ha.

1.1.3. Cauliflower

Seedbed preparation, seedling raising and transplanting:

a. Selected land for seedbed preparation should be solarized with a thin transparent polythene sheet (100 gauge) for one month before sowing of seed. Before covering the bed with polythene sheet dried well-rotted cow dung and sand (in case of clay soil) @ 40 kg each per $5m^2$ should be mixed. Bed should be moistened before covering and sides of the polythene sheet should be properly covered with soil to restrict the entry of air.

b. Before sowing of seeds the seed bed should be mixed thoroughly with 250 g neem cake powder, 50 g *Trichoderma viride* and 25 g *Pseudomonas fluorescens*.

c. Seeds are treated with *Pseudomonas fluorescens* powder @ 5 g with 100 g of seed along with little amount of water. Seeds should be dried in shade before sowing. After sowing, the seedbed should be watered lightly and then seeds are covered with a mixture of dried sieved cowdung and *Trichoderma viride* (Mixture 10 g of *Trichoderma* powder with 1 kg of cow dung powder).

d. Any neem-based insecticides (2 ml/*l*) is to be sprayed to the young seedlings whenever necessary.

e. Seedlings are to be transplanted to the main field after 25-30 days of sowing. Before transplanting seedling, roots are dipped in a slurry of *Azotobacter* (AZB) and Phosphorus Solubilizing Bacteria (PSB) mixture for 30 minutes (Slurry is prepared by mixing 75 g AZB and 75 g PSB for 1000 Nos. of seedlings.

Soil selection and land Preparation:

Deep summer ploughing is advisable. Well drained sandy loam to clay loam soil is suitable for cabbage cultivation. Before transplanting of seedlings, the land has to be ploughed and seeds of green manuring crops like *Dhaincha* or Sunhemp are sown in the month of May. After one and half month or two months of sowing young green manure plants are cut and incorporated with the soil by ploughing. Liming @ 10-12 q/ha should be done to raise soil pH depending upon the soil test result and mixed with the soil at least one month before transplanting of seedlings.

Application of manure and biofertilizers:

Rock phosphate @ 375 kg/ha and Vermicompost @ 5 t/ha should be applied before transplanting of seedlings.

Before planting of seedlings in the main field, microbial consortium (Azotobacter, PSB and KSB) is to be mixed with 2.5 t compost at a ratio of 1 : 100 (1.0% consortia in 100kg compost) and mixed properly and water is to be sprinkled and heaped. The heaps are to be covered with a gunny bag. After 8-10 days the mixture should be added to the pits meant for planting the seedlings. Wood ash and banana pseudo-stem ash are to be applied along with the organic manure

Plant protection techniques:

a) Follow crop rotation with non-cruciferous crops.

b) Deep summer ploughing helps in exposing resting stages of pests to predators and sunlight.

c) Use of resistant varieties against black rot. Destruction of crop residues after harvest and phyto-sanitation measures is to be adopted.

d) **Use of pheromone traps:** Pheromone traps with lures are commercially available for pests like DBM, *Plutella xylostella*; Cabbage butterfly, *Pieris* spp.; *Helicoverpa armigera* (Helilure); *Spodoptera litura* (Spodolure)etc. Install 8 traps/ha with lures for each pest, keep the distance of 1200 square meters between the traps. Trap should be installed in the field in such a way that the position of lure is always 6" above the crop canopy. Replace the lures once in 25-30 days depending upon the weather conditions. The trapped moths should be collected and destroyed regularly. ETL for *H. armigera* is 8 -10 moths per day per trap.

e) **Use of yellow sticky traps:** Yellow sticky traps should be set up for monitoring whitefly, thrips, etc. @ 20-25 traps/ha. Locally available empty tins can be painted with yellow colour and coated with castor oil/ grease on outer surface may also be used as

yellow sticky traps. However, yellow chart paper can be cut into the A4 size sheets and smeared it with 5 ml of mustard oil also a good alternative of costly YST.

f) 6 releases of *T. chilonis, T. priteosum* @ 1,00,000/ha with weekly intervals helps in controlling DBM and other lepidopteran pests .

g) Need based application of neem oil 500 ppm @ 5 ml/*l* or 1000 ppm @ 3 ml/*l* or 1500 ppm @ 1 ml/*l* as an alternative to chemical insecticides at an interval of 15 days.

h) Treat the seeds with *Trichoderma harzianum* based bioformulation like Org-Trichojal @5 g/liters of water + CMC @0.02% for 1 hrs followed by shade dry for 2 hrs prior to sowing can reduce the soil borne disease like damping off.

i) **Use of trap crop**: Two rows are to be sown with mustard as trap crop at the beginning and after 25 cabbage rows. Bold seeded mustard is more suited. Mustard is to be sown twice; first is at 15 days prior to cabbage transplanting, while the second one is at 25 days after transplanting. Thick showing of mustard i.e. 50-60 plants/m rows is recommended usually, the intercropped cabbage is free from infection during early stages. However, there may be some incidence at later stages. For this apply 5% NSKE.

j) Erect bird perches at least @ 15 nos./ha to provide roosting sites for predatory birds to consume insect larvae.

Interculture:

Irrigation:

The first irrigation is to be given immediately after transplanting and continued till the seedlings are established and subsequent irrigations should be given whenever required. Availability of water in soil should be as far as practicable uniform, otherwise splitting may occur.

Use of black mulch (50 micron) between the rows control weeds and also conserves soil moisture. Or weeding should be done at 20 and at 40 days after transplanting. Earthing up can be done in about 30 days after planting.

Yield:

Depending on variety, spacing and management practices the yield may vary from 250-280 q/ha.

1.1.4. Carrot (*Ducus carota L.*)

a) **Variety** : Early Nantes, Pusa Kesar and Chantenay

b) **Sowing time**: Oct- Nov

c) **Spacing**: seeds should be sown at a depth of 1.5 cm in lines spaced at 30 cm on flat

bed and seedlings are to be thinned out to 10 cm within rows at 10-15 days after emergence.

d) **Seed rate**: 5.5-7.0 kg/ha.

Soil selection and land Preparation:

Deep summer ploughing is advisable. Well drained sandy loam to clay loam soil is suitable for carrot cultivation. Before sowing of seeds the land has to be ploughed and seeds of green manuring crops like Dhaincha or Sunhemp are sown in the month of May. After one and half month or two months of sowing young green manure plants are cut and incorporated with the soil by ploughing. Liming @ 10-12 q/ha should be done to raise soil pH depending upon the soil test result and mixed with the soil at least one month before sowing of seeds.

Application of manure and biofertilizers:

Rock phosphate @ 30 kg/ha and Enriched compost @ 5 t/ha should be applied before sowing of seed. If enriched compost is not available well decomposed FYM @ 10t/ha also can be used.

Seed treatment:

Prior to sowing the seed should be well rubbed to remove the fine hairs. The seeds should be treated with a mixture of Azotobacter (AZB) and PSB @ 7.5 g each with 100 g seeds.

Plant protection techniques:

a) Deep summer ploughing helps in exposing resting stages of pests.

b) Destruction of crop residues after harvest and phyto-sanitation measures is to be adopted.

c) Use of repellant: 4% garlic juice should be sprayed whenever required.

d) Need based application of neem oil 500 ppm @ 5 ml/*l* as an alternative to chemical insecticides at an interval of 15 days against any leaf cutting insects.

Interculture:

i) **Irrigation**: Field should be properly irrigated before sowing to enhance germination and subsequent irrigations may be given periodically at 10-15 days interval depending upon the soil condition.

ii) **Weeding**: First weeding at 20 days and second at 40 days after sowing.

iii) **Earthing up:** It is to be done about one month after sowing.

Harvesting: After 65-70 days of sowing roots are ready to harvest.

Yield: 20-25 t/ha

1.1.5. Tomato *(Lycopersicon esculentum Mill)*

Varieties:

For organic farming of tomato, Open Pollinated Varieties (OPV) is preferred.

a) **Variety suitable for Assam:** Punjab Chhuhara, S-12, Punjab Kesri, Dwarf, Sioux, Pusa Ruby, VC-48-1, Arka Abha (BWR-1), Arka Alok (BWR-5) and BT-1.

b) **Sowing time:** Oct-Nov

c) **Planting time:** Nov-Dec

d) **Spacing:** 60 x 45 cm (Row to row X plant to plant)

e) **Seed rate:** 400 g/ha.

Crop Rotation:

Tomato being solanaceae family, rotation with non solanaceous crops like pulses/ legumes are usually recommended to avoid pests and diseases effecting tomato and also to enrich the nitrogen status of the soil.

Buffer zone:

In order to cultivate tomato organically a buffer zone of 7.5 to 15 m shall be maintained if the neighbouring farms are non-organic.

Land preparation:

The land may be ploughed and harrowed 3 or 4 times to obtain a fine tilth. About 10 tones of Farmyard Manure (FYM) or vermicompost/compost @ 1-1.5 t per acre is applied at the last ploughing. Green manuring is recommended for areas with assured rainfall and also for irrigated crop. Beds are prepared against the slope and after leveling the bed, field channels of 50 cm breadth are prepared at intervals of 1 m.

Planting material:

Tomato is propagated by seeds. Seed selection is an important aspect in organic tomato production. For raising nurseries, seeds of high yielding varieties with tolerance to pests and diseases may be used. They should be carefully selected from certified organic farms or from own seed plot which is raised organically. To start with, chemically untreated seeds from local high yielding varieties could also be used, in the absence of organically produced seeds.

Seed treatment:

Seeds should not be treated with any chemical fungicides or pesticides. Prior to sowing, the seeds should be treated with *Trichoderma* at the rate of 1 g per 150 g of seeds.

Nursery development:

In order to grow saplings in the nursery, beds of 1 m x 3 m are prepared with a height of 20 cm. Twelve to 15 beds are required for raising a nursery for planting 1 acre of land of tomato. Soils are exposed to high temperatures, to prevent possible pest and diseases from attacking the plants. After the beds are prepared 20 to 25 kg of farmyard manure along with 1.2 kg Neem cake is applied per bed. After necessary application of water, the beds are covered with thin white plastic sheets for raising the temperature without loss of moisture. Such practice will further eradicate harmful bacteria and pests.

For cultivation of tomato during Rabi season, seeds should be sown in the nursery during the month of August/September. The requirement of seed /acre is approximately 150 g. Sowing of the seeds should be done in straight lines drawn at an interval of 5 cm with 2 cm spacing between successive seeds implanted. Seeds are to be planted at a depth of 0.5 cm to 1 cm. After sowing the seed, a thin layer of soil should be used as covering. Then beds should be covered by thin nylon nets keeping a gap of one foot from the bed and fully secured from all sides by placing adequate soil on the borders of the net. This practice will prevent pest infestation in the saplings.

Planting:

Twenty to 25 days old seedlings should be used for transplanting in the main field with a spacing of 60 cm between rows and 50 cm distance between two successive plants. Transplantation is done on one side of the channel keeping a distance of 30 cm. In the initial period, irrigation from the field channel is found to be adequate.

Irrigation:

Irrigation should be provided once in 7-10 days depending on the soil and weather conditions

Cultural practices:

Irrigation:

The first irrigation is to be given immediately after transplanting and subsequent irrigation at 10-15 days intervals depending on soil condition. Effective, non-chemical weed management begins with well planned, diverse crop rotations, especially those including competitive cover (smother) crops. Attention is to be given to careful site selection to avoid introduction of weed seeds and other propagules. Weeds are a big nuisance as they take up the nutrients in the soil and can also harbor insects and diseases that cause harm to tomatoes. These weeds start growing four to five weeks after transplanting the tomato seedlings. Hence focus has to be on extensive weed control during this period. Weeds should not be allowed to grow in numbers. Organic weed control can be achieved by using organic matter as mulches as these

restrict weed growth. Crop rotation, mulching, sanitation, and shallow tilling also help in controlling the weeds. Use of black mulch (50 micron) between the rows control weeds and also conserves soil moisture. One weeding after 20 days of transplanting. After transplantation, regular weeding is required to be done to remove harmful weeds from the field. The plants can be provided support with the help of small bamboo sticks to increase the production.

Manuring:

In order to maintain a fertile soil, organic matter should be added to it regularly. If organic farming is being performed on own land since many years, the soil will have a good nutrient content. Compost / Farmyard manures can also be added to further enrich the soil. Application of organic manure is very important for tomato cultivation. Farmyard manure of 10 t or 1-1.5 t of vermicompost per acre is generally applied. To prevent the attack of soil borne plant pathogens, compost can be enriched with *Trichoderma harzianum* based bioformulation and FYM can be treated with *T. harzianum* based at the rate of 500 g per a tractor load of manure. After mixing the required amount of Trichoderma the manure should be allowed to remain in a heap covered with wet gunny bag for proper culturing. Research result obtained in AAU revealed that Rock phosphate @ 375 kg/ha and well decomposed FYM @10 t/ha or vermicompost @ 5 t/ha should be applied before transplanting of seedlings for high yield.

Plant protection

a) Crop rotation with French bean reduces the bacterial wilt disease incidence. Crop rotation with cereals, sesame, mustard and marigold to reduce nematode infestation.

b) Deep summer ploughing helps in exposing resting stages of pests.

c) Use of resistant varieties towards nematodes and bacterial wilt. Destruction of crop residues after harvest and phyto-sanitation measures is to be adopted.

d) **Use of pheromone traps**: Pheromone traps with commercially available lures for different pests like *Helicoverpa armigera* (Helilure), *Spodoptera litura* (Spodolure) and DBM can be install @ 8 traps/ha, keeping a distance of at least 1200 square meters between the traps. Trap should be installed in the field in such a way that the position of lure is always 6" above the crop canopy. Replace the lures once in 25-30 days depending upon the weather conditions. The trapped moths should be collected and destroyed regularly. ETL for *H. armigera* is 8-10 moths per day per trap.

a) **Use of yellow sticky traps**: Yellow sticky traps should be set up for monitoring whitefly, thrips etc. @ 20-25 traps/ha. Locally available empty tins can be painted with yellow colour and coated with castor oil/ grease on outer surface may also be used as yellow sticky traps. However, yellow chart paper can be cut into the A4 size sheets and smeared it with 5 ml of mustard oil also a good alternative of costly yellow sticky trap.

e) Intercropping a tall variety of marigold as a trap crop after every 16 rows of tomato can be practiced to control fruit borer. Raising of marigold nursery should be 15 days prior to tomato nursery, so that 25 and 40 days old tomato and marigold seedlings are replanted. Maximum eggs laying is observed on marigold flowers are the movement of larvae from marigold to tomato is not significant. Eggs and larvae are removed from fields along with the flowers. This trap cropping system also helps in reducing the root knot nematode infestation.

f) Six releases of *T. chilonis, or T. priteosum* @ 1,00,000/ha with weekly intervals starting from fruit formation stage helps in controlling Lepidopteran pests .

g) Need based application of neem oil 500 ppm @ 5 ml /*l* or 1000 ppm @ 3 ml/*l* or 1500 ppm @ 1 ml/*l* as an alternative to chemical insecticides at an interval of 15 days.

h) Grow cowpea or pulses on the border area of the main crop to build up natural enemy fauna.

Table 3. Tomato Diseases

Name	**Damage**	**Control**
Early blight (*Alternaria* blight)	Leaves have brown spots with concentric rings and yellow "halos"; Incidence increases in warm, humid weather	Resistant cultivars; Sanitation at season end; Mulching; crop rotation
Late blight	Leaves have bluish-gray spots; Leaves turn brown and drop; Fruits have dark brown, corky spots; Incidence increases with wet weather, warm days and cool nights	Resistant cultivars; Sanitation; Grow in poly hoop houses
Leaf spot (Septoria leaf spot)	Numerous small brown spots with gray or black centers; Leaves turn yellow and drop	Sanitation; crop rotation
Tobacco Mosaic Virus (TMV)	Distorted, small leaves and plants	Destroy infested plants

Bacterial spot; Bacterial speck	Small, dark spots on leaves; Brown, rough spots on fruit	Remove and destroy infested plants if severe
Bacterial canker	Leaves have brown edges; Wilted leaves; Fruit has very small, dark brown spot with white edges	Remove and destroy infested plants

Table 4. Other Problems of tomatoes

Name	Cause	Effect	Control
Blossom end rot; Blackheart	Lack of calcium	Sunken spot on blossom end of fruit; Blackheart is internal condition	Resistant cultivars; Spray with seaweed extract; Mulch to keep moisture level constant
Cracking	Warm, rainy weather after dry spell	Fruits split open	Resistant cultivars; Mulch to keep moisture level constant
Catfacing	Cool weather	Malformed fruit with scars near blossom end	Row covers
Blossom drop	Sudden temp. changes; Nights below 55°F; Hot weather; Too little light; Too much/Too little water; Too much fertilizer	Blossoms fall off before pollination occurs	Resistant varieties
Sunscald	Overexposure to sun caused by defoliation	Yellowish-white patches on fruit	Maintain plant vigor to avoid defoliation by insects and disease
N deficiency	Lack of nitrogen	Yellowing of oldest leaves; Stunted growth	Compost; Composted manure; Soybean meal; Dried blood; Fish emulsion; Legume cover crop

P deficiency	Lack of phosphorus	Reddish-purple leaves	Compost
K deficiency	Lack of potassium	Bronze spots between veins of leaves; Underdeveloped roots	Compost; Wood ashes

Harvesting

The crop will be ready for harvest in about 2- 3 months after planting. The harvesting of the tomatoes is done as per the requirement of the market and in a typical season 8 to 10 harvesting is done to feed the market as per its requirement.

Yield: 25-30 t/ha.

II. SPICES

1.2.1. Bhut Jolokia

1. Botanical name:	*Capsicum chinense*
2. Variety:	Local types are cultivated by farmers. *Bhut jolokia* has several types based on size, shape and colour. Dark green types have comparatively lesser incidence of diseases as compared to Light green types.
3. Season of Cropping:	Plains – Oct-Dec with irrigation and Jan-March without irrigation Hills – Jan-April
4. Soil:	The crop grows in a wide range of soils. Well drained sandy loam rich in organic matter having good water holding capacity with pH 6.0-6.5.
5. Sowing time:	Sowing in Oct/Nov in the plains and Jan/Feb in the hills
6. Land preparation:	The field should be prepared well with ploughing and harrowing. Cross ploughing is advocated to avoid the possibility of remaining un-ploughed strip.
7. Seed requirement:	About 10g seeds are required in a *bigha* of land. One ha land requires about 75g seeds
8. Seed Bed Preparation and Seedling Raising	**Seed collection**: ● Collect mature red ripe fruits from authentic source. The mother plants should be free of diseases and in bearing of healthy and true to type fruits ● Extract the seeds manually using blades and forceps. ● Always use hand gloves and spectacles for such work. ● Wash the freshly extracted seeds in clean water and dry under shade.

	Seed sowing: ● Prepare the nursery bed in well drained sunny area measuring 5 1.00 m (w) x 15 cm (h) with length as per requirement. ● Apply 20 kg sand or silt and 20 kg well decomposed sieved cattle manure or compost per 10 m^2 area and mix thoroughly. ● Sow the germinated seeds thinly with great care in furrows spaced at 2.5 cm. ● Cover the seeds with a thin layer of treated mixture of sand and sieved cattle manure. The surface should be levelled and firmed. ● Water the bed lightly using water can. ● Place an overhead insect-proof net (40 mesh) structure. ● Regularly inspect for occurrence of any insect-pest or disease. ● Allow maximum sunlight to the growing seedlings. ● The seedlings get ready for transplanting in 30-45 days after sowing when they attain 10-15 cm height. ● Harden the seedlings before lifting by gradual reduction of water for about a week. ● Copiously water the bed 6 h prior to lifting for minimizing root damage during removal of seedling and maintaining plant turgidity.
9. Bed preparation for transplanting and drainage:	● Raised bed (15 cm) of 2.40 m width and convenient length may be prepared keeping 40 cm wide inter-bed channels. The channels should be connected to drainage ditch of deeper level. ● Pits (45cm x 45cm x 45cm) at a spacing of 100 cm x 100 cm leaving 20 cm longitudinally on both side of the beds

10. Transplanting of Seedlings:	• Seedlings of 30-45 days of age are suitable for transplanting. This operation should preferably be carried out in the afternoon. • Each bed can accommodate 3 rows of seedlings
11. Spacing:	100 cm x 100 cm
12. Manure, Fertilizers & Chemicals	• FYM @ 1.3 t/*bigha* (10 t per ha) to be applied at final land preparation and mixed well. The FYM should be applied @ 1kg/pit. • Application of enriched compost @ 10ton/ha or 5ton enriched compost/ha plus biofertilizer • The pits should be prepared 30 days ahead of transplanting. • Apply Azotobacter 5g, PSB 5g and Biofor pf 100g per pit within 7 days of transplanting
13. Irrigation	Bhut jolokia needs adequate moisture for growth and development. Plants are irrigated at 70-75% field capacity. Sprinkler irrigation system can suitably be used. Use of drip system results in better water use efficiency with 30% water saving and promotes crop growth and fruit yield.
14. Intercultural Operations	• Mulching with organic material can also be practised for suppression of weeds. Mulching should be done with shredded organic materials for conservation of soil moisture, suppression of weeds and increase in soil organic matter. • Staking may be required to provide mechanical support to the plants.
15. Disease management	**<u>Damping-off/Collar rot</u>** • Adopt proper nursery raising technique. • Apply Biozium (*T. harzianum*) @ 20 ml/kg against *P. aphanidermatum* • Seed treatment with *Trichoderma harzianum* based bioformulation like org-Trichojal @5 ml/kg of seed against *Rhizoctonia solani* and *Fusarium* spp.

	Fruit rot ● Collect the rotten fruits and destroy them. **Bacterial wilt** • Soil application of *Trichoderma viride* based bioformulation like Bioveer @ 2kg/m^2 or *Pseudomonas fluorescence* based bioformulation like Biofor-Pf-2 @ 2kg/m^2 ● Follow 3-year crop rotation in infested soil by including non-host crops like crucifers, maize etc. ● Apply biocontrol agent formulation like Biofor pf, etc. ● Infected plants MUST be discarded as soon as possible. **Leaf curl and Little leaf** ● Remove all the infected plants and weeds. ● Grow seedlings in netted nursery. ● Use 2-3 rows of trap crops like cotton, marigold along the border. Sow the border crop at least 60 days before transplanting of Bhut jolokia seedlings.

1.2.2. Chilli

Variety:

NP-46 A, Pusa Jwala and selected local varieties like Suryamukhi, Krishna, Khorika jolokia and Balijuli

Soil:

Well drained sandy loam rich in organic matter with pH 6.0-6.5

Seed bed preparation and seedling raising:

a) Seeds are to be sown in the nursery and one month old seedlings are transplanted to the main field. An area of 0.01 ha is required for raising seedlings for one hectare.

b) For sowing the seeds, raised seed beds of 90 to 100 cm width and convenient length are prepared in open space with fertile topsoil to which well decomposed organic matter has been incorporated.

c) Seed rate: 600-700 g/ha. 3-4 g of seeds should be sown per 10 sq. mtr

d) Seeds should be sown thinly in lines spaced at 40-45 cm and seedlings are thinned out to proper spacing later on

e) Care should be taken to prevent incidence of damping off in the nursery. For this add one kilogram of *Trichoderma* to 100 kg of dried farmyard manure and 10 kg of neem cake spread under shade to which water is sprinkled for maintaining moisture. Keep the mixture for fifteen days with intermittent turning.

f) To the nursery soil, add 1 kg of PGPR mix 1 at the time of bed preparation.

g) After sowing the seeds, mulch with green leaves and irrigate with a rose can daily in the morning. At the time of irrigation, add *Pseudomonas fluorescens* @ 20 g/*l* at frequent intervals.

h) Remove the mulch immediately after germination of the seeds. Addition of diluted (25 g/*l*) cow dung slurry or cow urine (diluted 8 times) increases the vigour of the seedlings.

i) Restrict irrigation one week before transplanting and irrigate heavily on the previous day of transplanting.

Time of panting: December/January

Spacing: 45 cm x 45cm

Land preparation and transplanting

Land is prepared to a fine tilth by thorough ploughing or digging. Well rotten organic manure is incorporated in the soil and seedlings are transplanted in shallow trenches or on ridges / leveled lands according to season. Transplanted seedlings may be given temporary shade for 3-4 days during hot days.

Manuring

a) Apply lime @ 500 kg/ha based on the acidity of soil 15 days before transplanting.

b) Apply FYM or compost @ 25t/ha as basal dose to which *Trichoderma* and PGPR mix 1 each @ 2.5 kg /ha are mixed and kept for 15 days in shade.

c) Apply *Pseudomonas* and AMF at the time of transplanting. Instead of FYM, poultry or powdered goat manure @ 1 t/ha can be applied.

d) Dip the roots in 2% Pseudomonas or PGPR mix 1 before transplanting to the field.

Top dressing of biofertilizers

Top dressing can be done at 7-10 days interval with any one of the following

a) Soil application of fresh cow dung slurry @ 1 kg/10 *l* (50 kg/ha)

b) Soil application of biogas slurry @ 1 kg/10 *l* (50 kg/ha)

c) Soil application of cow's urine 500 *l*/ha (8 times dilution)

d) Soil application of vermiwash-500 *l*/ha (8 times dilution)

e) Soil application of vermicompost / poultry / powdered goat manure-1 t /ha

f) Soil application of groundnut cake1 kg/10 *l* (50 kg/ha)

g) Foliar spray can be given with cow dung slurry/ vermiwash / cow's urine.

After cultivation

a) Give pre-transplanting irrigation, if the soil is not moist enough. Irrigate at two or three days' intervals during summer.

b) Stake the plants if necessary.

c) Weeding followed by organic manure application and earthing up may be done at one and two months after transplanting.

d) Provide mulch in the field throughout the crop growth period with materials like green leaves, plant residues, decomposed coir pith, coconut husk, straw, etc.

e) Use biodegradable plastic film (20-25 Micron) as mulch or apply rice straw mulch @ 4-6 t/ha (5-6 cm thick) followed by one hand weeding at 75 days after planting for effective weed management

Plant Protection

I. Insect pests:

a) Chilli Aphids: Spray neem oil -garlic emulsion (2%). Spray *Verticillium lecanii* like Org-Vertijal @ 5 ml/*l* or *Metarhizium anisopliae* based bioformulation like Org-Metajal @ 5ml/*l*. Release green lacewing bugs @ 50,000 eggs/ha.

b) Jassids: Spray neem oil-garlic emulsion (2%) or lemon grass/ginger extracts (10%)

c) Thrips: Spray neem oil-garlic emulsion (2%) or lemon grass/ginger extracts (10%)

d) Mite: Apply neem oil 5% or neem oil + garlic emulsion 2%.Spray diluted rice water once in 10 days against mite.

e) Chilli White fly: Spray *Verticillium lecanii* based bioformulation like Org-Vertijal @ 5 ml/*l* or garlic emulsion (2%). Place Sticky yellow traps.

II. Nematode:

a) Apply Eupatorium and neem leaves, neem cake, rice husk, wood shavings, castor cake @ of 100g/m2. Apply VAM, Plant Growth Promoting Rhizo bacteria, Paceilomyces to soil @ 2kg/ha. Seed treatment with Bacillus macerans @ 3% W/W (2.5 kg/ha) and drenching with B. macerans @ 3% solution 30 days after sowing.

III. Diseases

a) **Damping off:** Sow the seeds in raised beds prepared in open area during summer months. Pre-inoculation of AMF in furrows @ 200 g/m^2. Apply lime in nursery bed. Use *Trichoderma*, *Pseudomonas fluorescens* and PGPR mix II @ 20 g/*l*. Neem cake can be applied @ 250 kg/hectare to reduce soil inoculants or apply Biozium (*T. harzianum*) @ 20 ml/kg against damping-off causing pathogen *P. aphanidermatum*)

b) **Leaf spot:** Spray *Pseudomonas fluorescens* (2%) Spray Bordeaux mixture (1%).

c) **Bacterial wilt:** Soil application of *Trichoderma viride* based bioformulation like Bioveer @ 2 kg/m^2 or *Pseudomonas fluorescence* based bioformulation like Biofor-Pf-2 @ 2 kg/m^2

d) **Bacterial leaf spot:** Cultivate resistant varieties (KAU). Use lime in the field. Cultivate marigold in field. Soil application of *Pseudomonas fluorescens* or PGPR mix II @ 20 g/*l* at 15 days interval. Seedling root dip and foliar spray of *Pseudomonas fluorescens* @ 1-2%.

e) **Chilli leaf curl virus:** Spray neem-based insecticides (2 ml/*l*) to control the vectors. Grow resistant varieties like Punjab Lal & Pusa Sadabahar. Spray neem-based insecticides (2 ml/*l*) to control the vectors. Grow 5-6 rows of maize around the crop at least 50 days before transplanting. Keep the plot weed free.

Storage of seeds

Packaging of seeds in polythene cover (700 gauges) increases the storage life up to 7 months. Seeds treated with *Trichoderma* and *Pseudomonas* (each @ 6 g/kg seed) can be stored up to 5 months.

Yield

Depending on variety, spacing and management practices the yield may vary from 50-70 q/ha.

1.2.3. Ginger (*Zingiber officinale*)

Climate and soil:

Ginger is a tropical plant adapted for cultivation even in regions of subtropical climate such as the high ranges. It prefers a rich soil with high humus content. Being an exhausting crop, ginger is not cultivated continuously in the same field but shifting cultivation is practiced. The crop cannot withstand water logging and hence well drained soils are preferred for its cultivation. It is shade tolerant/loving crop with shallow roots and therefore suitable for intercropping and as a component in the homesteads where low to medium shade is available.

Varieties: Nadia, Moran, Jorhat, China

Planting time: March-April

Spacing: 25 cm x 25 cm

Seed rate:

Ginger rhizomes with one or two good buds each weighing about 10-15 g is used for planting. A total of 10-15 q of rhizomes are required for one hectare of land.

Method of planting:

Ginger rhizome bits of 10-15 g in weight are placed in furrows at a spacing of 25 cm x 25 cm and at a depth of 4-5 cm. Then the rhizomes are covered with soil. Before planting, soak the seed rhizomes in a solution containing *Pseudomonas* @ 20 g/*l* for 30 minutes and dry under shade.

Manuring:

FYM / compost @ 25 t as basal and 3t/ha each at 60 DAP and 120 DAP are applied. FYM, *Trichoderma*, neem cake mixture @ 100 g/planting pit is applied at the time of planting. Vermi compost may also be used at a reduced dose instead of FYM according to availability. *Azospirillum* @ 2.5 kg /ha / PGPR mix I as basal is applied. The same dose is applied at 120 DAP.

Mulching:

Immediately after planting, the beds should be thickly mulched with green leaves @ 15 t/ha. Mulching with green leaves is done twice @ 7.5 t/ha first 45-60 days and second 90-120 days after planting. Green manure crops like dhaincha and sunhemp may be grown in the interspaces of beds, along with ginger.

After cultivation

Weeds are removed by hand-weeding before each mulching. Weeding is repeated according to weed growth during the fifth and sixth month after planting. Removed weeds should be recycled by way of mulching. Earth up the crop during the first mulching and avoid water stagnation.

Plant Protection

I. Nematodes:

Neem cake @ 1 t/ha should be applied at planting. The same dose should be applied again at 45 DAP.

II. Diseases:

a). Rhizome rot and bacterial wilt:

a. Sites having proper drainage should be selected for ginger cultivation. The seed rhizomes are soaked in 5% talc formulated (50 g/*l*) suspension of *Pseudomonas fluorescens* P_1 for 15 minutes before planting. To avoid the infection of disease organic manure enriched with *Trichoderma* should be at the time of planting.

b) Spraying and drenching the plant with *Pseudomonas fluorescens* P_1 / PGPR mix II at 45 days after planting (onset of monsoon) should be done and spraying and drenching is repeated at monthly intervals based on disease incidence and intensity

Harvesting and processing:

For vegetable ginger, the crop can be harvested from sixth month onwards. For dry ginger, the crop is harvested in between 245-260 days. After harvest, the fibrous roots attached to the rhizomes are trimmed off and soil is removed by washing. Rhizomes are soaked in water overnight and then cleaned. The skin is removed by scraping with sharp bamboo splits or such other materials. Never use metallic substances since they will discolour the rhizomes. After scraping, the rhizomes are sun-dried for a week with frequent turns. They are again well rubbed by hand to remove any outer skin. This is the unbleached ginger of commerce.

1.2.4. Turmeric (*Curcuma longa*)

Climate and soil:

Turmeric is a tropical herb and can be grown on different types of soil under irrigated and rainfed conditions. Rich loamy soils having good drainage are ideal for the crop. It is a shade tolerant crop with shallow roots suitable for intercropping and also as a component crop in the homesteads where low to medium shade is available.

Seed material

Whole or split mother rhizomes are used for planting. Well developed, healthy and disease-free rhizomes are selected. Mother or finger rhizome @ 25 q t is required for one hectare.

Varieties: Tall Clone, Megha, Lacadan

Season and method of planting

Planting is done during April with the receipt of pre-monsoon showers. Rhizomes are placed in furrows at 10 cm depth at a spacing of 45cm x 25 cm. and covered with soil or dry powdered cattle manure.

Manuring:

Treatment of rhizome with microbial consortia (Azospirillum + PSB + KSB) as slurry

@ 40 g consortia/ kg of dry cowdung at planting for Turmeric along with application of FYM 10 t/ha at the time of final land preparation. Such preparation will be sufficient to treat 5 kg of rhizome. As such for one hectare area 500 kg of cowdung and 20 kg microbial consortia will be required.

After cultivation:

Weeding is done thrice at 60, 120 and 150 days after planting, depending upon weed intensity. Removed weeds should be recycled by way of mulching. Earthing up the crop is done after 60 days of planting.

Plant protection

I. Insect pests:

a). Rhizome rot, wilt and leaf spot diseases: The seed rhizomes are dipped in 5% suspension *of Pseudomonas fluorescens* for 15 minutes before planting. Organic manure enriched with *Trichoderma* is applied at the time of planting. Spraying and drenching of the plants is done with *Pseudomonas fluorescens* P_1 / PGPR mix II at 45 days after planting (onset of monsoon). Spraying and drenching is repeated at monthly intervals based on disease incidence and intensity.

Harvesting and curing:

Time of harvest depends on the variety and it usually extends from January to March. Harvest early varieties at 7-8 months, medium varieties at 8-9 months and long duration varieties at 9-10 months after planting.

III. FRUITS

1.3.1. Banana (*Musa* spp.):

Banana prefers tropical humid lowlands and is grown from the sea level to 1000 m above MSL. It can also be grown at elevations up to 1200 m, but at higher elevations growth is poor. Optimum temperature is 27°C. Soils with good fertility and assured supply of moisture are best suited.

Season:

Rain fed crop: April - May

Irrigated crop: August - September

The time of plantings are to be adjusted so as to avoid high temperature and drought at the time of emergence of bunches (7-8 months after planting).

Variety: Giant Cavendish/Malbhog

Preparation of land:

Field is prepared by 1 ploughing and 2 harrowing followed by leveling.

Pit making:

Pits are dug at a spacing of 1.8x1.8m. Pit size 50cmx50cmx50cm. In low lying areas mounds can be prepared for planting.

Selection of suckers:

a) Sword suckers of 3-4 months old disease-free healthy clumps should be selected. Suckers should be removed one week after the harvest of the bunch.

b) Pseudo stem should be cut back to a length of 15-20 cm from corm and old roots are to be removed. Rhizome weevil (black tunnels) and nematode (darkened lesions) infected portions of corm and roots should also be removed.

c) The rhizome should be dipped in hot water (50°C) for 20 minutes to prevent nematode infestation.

d) The rhizomes are to be smeared with cow dung solution and ash and dried in the sun for about 3-4 days and stored in shade up to 15 days before planting.

e) Soaking the suckers in *Pseudomonas fluorescens* solution (2%) for 30 minutes before planting is beneficial.

Spacing: 1.8 m × 1.8 m

System of planting: Square system of planting.

Total number of plants: 3086 Nos. per hectare

Planting:

Suckers should be planted upright in the center of pits with 5 cm pseudo stem remaining above soil level. Organic manures and *Trichoderma harzianum* (100 : 1) should be applied in the pit before planting. Soil should be pressed around the sucker to avoid hollow air spaces.

Manuring:

a. FYM or compost or green leaves @ 10 kg/plant at the time of planting.

b. 500 g of lime in the pit and allow to weather.

c. Vermicompost @ 2 kg / pit at the time of planting.

d. Groundnut cake/ neem cake @ 1 kg /pit at the time of planting.

e. N, P and K biofertilizer- PGPR mix I/microbial consortium @ 50-100 g/pit should be applied at the time of planting. The biofertilizer should be mixed with 5 kg FYM. It should be ensured that there is enough moisture in the soil at the time of

application.

f. Panchagavya 3% as foliar spray three times at 3rd, 6th, and 9th months after planting

g. After planting bananas, sunhemp / dhaincha/ cowpea should be sown, adopting a seed rate of 50 kg/ha (20 g/plant). Incorporate the crop into the soil 40 days after sowing. Repeat sowing of green manure crop and incorporate into soil 40 days after sowing. Compost made from banana leaves and bunch stalks is rich in potassium content.

Additional nutrient requirement:

Apply FYM @ 15 kg, Rock phosphate @ 300 g and Ash @ 1.5 kg/plant

It is preferable to apply organic manures in two equal split doses at 2nd and 4th month after planting.

Irrigation:

a. Irrigation is needed once in three days during summer months.

b. Good drainage should be ensured; water logging should be prevented.

c. About 6-10 irrigation per crop may be given depending upon soil conditions and frequency of rainfall

Weed control:

By growing cowpea in the inter spaces during early stages, completely control weeds. Hand weeding by giving 4-5 surface diggings (depending upon weed growth) gives good weed control. Deep digging should be avoided. Do not disturb soil should not be disturbed after plants start producing bunches. If green manure crop is grown, weeding operations can be reduced to 1-2 diggings. Mulching is an effective practice for controlling weeds.

De-suckering:

Side suckers produced till the emergence of bunch should be removed. One or two suckers produced after the emergence of the bunch should be retained.

Inter cropping:

Amaranth, colocasia and elephant foot yam can be profitably intercropped with banana by adopting organic method of cultivation.

Plant protection:

I. Insect Pests:

i) Banana pseudo stem weevil (*Odoiporus longicollis*)

Pseudo stem weevil is a serious pest of banana. It attacks the crop from 6th month onwards. Adult female weevil inserts eggs into the air cavities of the pseudo stem. The grubs which emerge out feed on the internal tissues, weakens the pseudo stem and it collapses in due course.

Management

a. Field sanitation – all dried leaves over the pseudo stem should be removed.

b. Severely infested plants with rhizome in full should be removed and destroyed by burning all the life stages of the insect pest.

c. Pseudo stem of harvested plants should be destroyed.

d. Remove the loose dry sheaths of the pseudo stem of plants from 5th month onwards and any of the below mentioned methods should be followed.

e. Swabbing mud slurry around the pseudo stem: If infestation is noticed, neem oil emulsion @ 3 % is to be mixed in the mud slurry (30 ml/*l*) used for swabbing.

f. Application of neem oil 1500 ppm @ 5 ml /*l* on the pseudo stem and the leaf axils is to be filled at monthly intervals starting from 5th month onwards.

g. Application on the pseudo stem by spraying and leaf axil filling with entomopathogens, namely, *Beauveria bassiana* based bioformulation like Org-Beauverijal or *Metarhizium anisopliae* based bioformulation like Org-Metajal @ 15 ml/*l*.

h. Spraying of entomopathogenic nematode (EPN) @ one billion/ha over the pseudo stem or place three cadavers containing EPN s in alternate leaf axils at fortnightly intervals.

i. Split pseudo stem pieces of 2 ft long can be placed in the ground when plants are 5 months old. Weevils in the trap are to be collected and destroyed daily.

ii) Banana Rhizome Weevil (*Cosmopolites sordidus*)

Adult females puncture the rhizome and insert eggs through the holes. Grubs feed on the tissues and damage the rhizome. When growing point is damaged, the plant is killed. Symptoms are death of unopened pipe leaf, delay in emergence of new leaves and reduction in leaf number and bunch size.

Management

a) Only healthy, pest free planting material should be selected.

b) The land should be ploughed deep so as to remove old rhizomes and expose inner

soil layer to sun.

c) Outer layer of rhizome (Paring) are to be cut and removed so as to remove eggs and young ones of weevils. Suckers are to be dipped in slurry made of cow dung and ash and dried in shade.

d) Split pseudo stem pieces of 2 ft long can be placed in the ground when plants are 5 month old. Weevils in the trap are to be collected and destroyed daily.

e) Pheromone trap should be used with Cosmolure / Cosmolure + (an aggregation pheromone) to attract both sexes of weevil. The trap is to be kept throughout the year; changing the site when the number of weevils collected is reduced. Pheromone sachet is to be changed every45 days.

f) Soil around plants should be drenched or the plants are to be sprayed with entomopathogens like *Beauveria bassiana* (dosage same as for pseudo stem weevil). The quantity needed will depend on stage of the crop.

g) Crushed neem seed should be applied to the pit @ 1kg/plant

iii) Aphid (*Pentalonia nigronervosa*)

Aphid acts as a vector for the transmission of viral diseases of banana. Spraying of *L. lecanii* @ 1 x 107 spores/ml should be sprayed, whenever aphid population is noticed.

iv) Banana fruit and leaf scarring beetles, *Nodostoma subcostatum*

a. Bunch covering with perforated plastic bags was the most promising in reducing the beetle.

b. Four-time filling of leaf axil with *Beauveria bassiana*

b) Four spray of Neem product (Azadiractin, 1500 ppm) @ 5ml/*l*

II. Nematodes

Major species attacking banana are burrowing nematode (*Radopholu ssp)*, root knot nematode (*Meloidogyne incognita),* root lesion nematode (*Pratylenchus coffeae)* and cyst nematode (*Heterodera oryzicola)*. Reduction in the number of leaves, bunch weight and number of fingers are the symptoms.

Management

a) Paring the rhizomes and dipping in hot water at 45 -50°C for 20 minutes will control nematodes.

b) Neem cake @ 1 kg/plant is to be applied at the time of planting.

c) Intercropping banana with sunhemp or marigold also reduces nematode population.

III. Diseases:

i). Sigatoka leaf spot (*Mycosphaerella* sp.):

a. All severely affected leaves are to be cut and burned.

b. Need based sprayings are to be given depending upon the severity of the disease.

c. 1% Bordeaux mixture is to be sprayed soon after the appearance of the initial symptoms of the disease. The disease appears with the commencement of southwest monsoon.

d. Power oil (Mineral oil) 1% emulsion is effective in controlling the disease.

e. Bio agents like *Pseudomonas fluorescens* @ 20 g/*l* (2%) or *Bacillus subtilis* @ 5g/ *l* is effective against sigatoka leaf spot disease.

f. Growing of resistant/less susceptible varieties

ii). Panama Wilt (*Fusarium oxysporum* f. sp. *cubense)*

a) Affected clumps along with corms are to be removed and destroyed

b) Lime @ 500g to be applied per pit and allow to weather

c) Neem cake @1 kg per pit can be applied at the time of planting followed by irrigation.

d) Application of soil-based inoculums of AMF 500 g (soil-based inoculums containing 40spores per gm of soil), *Trichoderma harzianum* (50 g) and *Pseudomonas fluorescens* (50 g) or PGPR mix 1 is effective.

e) The planting material are to be dipped in 2% *Pseudomonas* before planting

iii). Bunchy top disease: Virus disease of banana transmitted by aphids

a) Use disease free suckers for planting.

b) Eradication of disease affected plants.

c) Spraying neem-based insecticide on the pseudostem to control the vector.

d) Spraying of *Vertilicillum lecanni* based bioformulation like org-Vertijal or *Metarhizium* based bioformulation Org-Metajal @ 5 ml/*l* of water whenever aphid population is noticed.

iv). Banana Bract Mosaic Disease (Kokkan disease): Virus disease transmitted by aphids

a) Use of disease-free healthy suckers for planting.

b) Eradication of disease affected plants as and when noticed.

c) Spraying of neem-based insecticide to control the vector.

v). Infectious Chlorosis (Cucumber Mosaic Disease)

a) Use disease free suckers for planting

b) Eradication infected plants.

c) Use neem-based insecticide to control the insect vector.

d) Growing of cucurbitaceous vegetables as intercrop should be avoided in banana

Yield

The yield of banana depends on variety, plant diversity, management practices etc. The tall varieties yield 12-15 t/ha while the dwarf varieties yield 25-30 t/ha.

1.3.2. PINEAPPLE

Climate:

Pineapple grows well in humid tropical conditions. The optimum altitude for pineapple cultivation is 1100 m above mean sea level. The acidity of the flesh increases at very high elevation. Pineapple is a drought resistant crop and optimum rainfall requirement is 1000-1500 mm per year. It has been reported that shade intensity up to 50 per cent is optimum for satisfactory crop growth and yield; and it can be grown successfully as an intercrop in areca nut, coconut gardens.

Soil:

The best soil for pineapple cultivation is well drained, sandy loam with high organic matter content. The pH should be within the range of 4.5 to 6.0. The plant cannot tolerate water logging conditions and there should be a proper drainage facility if there is an impervious sub soil. Heavy soil should always be avoided.

Varieties:

The important pineapple varieties for Assam are Kew, Giant Kew and Queen.

The varieties differ in growth habit and fruit size.

Selection of planting materials:

Suckers and slips are preferred for planting as they come to bearing earlier than the crown and produce larger fruits. The suckers of 501-750 g and slips of 301-400 g are considered as ideal planting materials.

Planting time:

Planting of pineapple suckers can be done from April to October. However, April-May planting is considered as the best time for better growth of the plants in Assam.

Planting system:

Pineapple is planted in a double row bed system for convenient intercultural operations. The spacing is 30 cm x 60 cm x 90 cm *i.e.* the spacing between plant to plant is 30 cm in rows, row to row is 60 cm and 90 cm between two double rows. In this spacing, 44,000 numbers of plants can be accommodated.

Manures requirement and their application:

Pineapple removes large amounts of soil nutrients. Repeated cultivation of this crop in the same land leads to drastic reduction in yield after a few years due to exhaustion of nutrients in soil. For organic cultivation of pineapple, 10-15 t of FYM, 8 q of rock phosphate, 2 t neem cake, 45 kg *Azospirillum*, are required for one crop in one hectare.

Cultural operations:

Earthing up:

It is an essential operation in pineapple cultivation to provide better anchorage to the plants. After application of biofertilizers, earthing up should be carried out. The roots of pineapple are very shallow; the plants eventually lodge under high rainfall areas. Lodging of plants at the time of fruit development results in lopsided growth, uneven development and premature ripening of fruits. High density planting minimizes the risk of lodging as the plants prop each other.

Weed management:

Weeds are a serious menace in pineapple gardens. Periodical weeding is must to ensure better performance of crop. Weeding done by manually increases the cost of production. Mulching with any organic materials like paddy straw, pineapple trash, saw dust etc. or black polythene sheets is essential particularly under rain-fed conditions to reduce the growth of weeds and conserve soil moisture.

Removal of suckers slips and crowns:

Suckers start growing with the emergence of inflorescence while slips grow with the developing fruits. With the increased number of suckers fruit size increases but the fruit maturity is delayed with the increase in number of slips. If slips are not required for further planting, slips should be removed as early as possible. Crowns are not removed as this will affect the appearance of fruit.

Ratooning:

The first crop harvested after planting is termed as ‘the plant crop’. If suckers are retained in the same place to develop the next crop, it leads to the ‘first ratoon’. The practice of allowing the plant to produce consecutive crops without replanting is called ‘ratooning’. In

Assam, continuous rationing is practiced for more than 25-30 years. If rationing is continued for several years, yield gradually decreases. It is therefore advisable to practice the cropping to 3 crops (plant crop followed by 2 ratoon crops) which is possible in 5 years of planting.

Flowering and fruit set:

One of the major problems in pineapple cultivation is the highly erratic flowering behaviour of plants. Even under ideal management conditions, only about 20-50 per cent of the plants flower after 15-18 months of growth. It affects continuous and regular supply to the canning factories and markets. Generally, flowering in pineapples occurs during Feb- March and only few plants flower during June-July. Regulation of flowering in pineapple is very much essential. Pineapple plants highly respond to the applied chemicals used for artificial induction. Pineapple can be artificially induced by application of ethrel @ 100 ppm. Flower inducing chemicals should be applied when the plants produce more than 35 numbers of leaves to harvest marketable size fruits. The flower inducing chemicals are applied in the early morning when there is no rain. Plants start flowering in 40 days and about 98 percent of plants come to flower within 70 days after application of flower inducing chemicals.

Fruit growth and development:

After flowering, fruits mature in about 130-150 days depending upon variety and climatic condition. The following treatments can be adopted to improve size and quality of pineapple fruits.

- Slips should be removed immediately after emergence, if number of slips increases then fruit size and quality will decrease.
- Removal or pinching of the innermost whorl of leaflets along with the growing tips of the crowns after 40 days of flowering is found to increase the fruit weight by 15-20 per cent as compared to non-pinched plants.
- The growth of suckers should be encouraged as it has positive impact on size and quality of pineapple fruits.

Harvesting of fruits:

Yellow colour development at the basal half to two-third portion of fruit is taken as the optimum stage of harvest for local markets. To prevent losses during transportation to the distant markets, fruits are harvested when 1/3rd to 1/4th basal portion of fruits become yellow. Harvesting should be done with a sharp knife by severing the fruit stalk retaining 5-7 cm of the stalk. Slips and a part of the crowns are removed carefully. Great care should be taken in handling the fruits as any mechanical injury on fruit skin may cause the fruit to rot quickly.

1.3.3. Assam lemon

Cultivar: Assam lemon (standing crop)

Spacing: 3 m x 3 m

No. of plants: 1111 per hectare

Nutrient Management:

a) Vermi compost @ 4 kg/plant before flowering
b) Wood ash @ 5 kg/plant before flowering
c) Neemcake @ 3 kg/plant in two splits March/April and September/October
d) Green manuring with Dhaincha: Dhaincha seeds are to be sown between rows of Assam lemon plants and incorporated into the soil after sufficient growth.

Plant Protection:

I. Insect pest:

i) Aphids, whiteflies, Leaf miner:

Spray neem oil 1500 ppm @3-5 ml/*l* of water at bud burst stage and repeat after 10 days. If infestation is severe prune the infected branches. Spraying of Biotime (AAU Product) (mixture of *P. fluorescens*, *T. viride* and *M. anisopliae*) @ 0.2% is also against citrus leaf miner.

ii) Bark eating caterpillar:

Apply Bordeaux paste on the trunk up to a height of 60 cm during winter and early summer.

II. Nematode:

Apply 200 g *Trichoderma viride* (enriched with vermicompost/FYM)* per plant around the base for management of citrus nematode*, Tylenchulus semipenetrans.*

* 20 kg *Trichoderma viride* mixed with 180 kg of Vermicompost / well decomposed FYM. This mixture should be covered with gunny bag and to be placed in shade for 15 days. Periodical sprinkling with water to be done in order to maintain adequate humidity. 200 g of this mixture should be applied around per plant (1 m away from the base and at 6 inch deep) twice in a year, along with application of fertilizer along with sufficient amount of organic matter. This amount is sufficient for one hectare plantation.

III. Diseases:

i). Damping off, Root and Collar rot: Avoid injuries to trunk and root

ii). Powdery mildew: Prune water shoots regularly

iii). Citrus Canker:

a. Prune and destroy infected twigs
b. Control leaf mine.
c. Spray Biotime (mixture of *P. fluorescens, T. viride* and *M. anisopliae*) @ 0.2%.

Harvesting:

After the second year of planting the plants start bearing. Bearing of Assam lemon is continuous throughout the year. Harvesting should be done when the fruits are fully matured. Peak period of bearing is July to September

Construction of low cost vermicompost unit

Design and specification of low-cost vermicoposting unit

1. **Dimension: 2.5 m (L) x 0.91 m(B) x 0. 76m (D)**

2. **Materials to be used:**

a) Bamboo structure for the shed over the tank and construction of vermicomposting unit
b) Roof: UV stable silpulin/Thatch
c) Sides: Locally available material e.g. Dried banana leaves/ agroshed Net

d) Pit: A pit connecting the vermicomposting unit. A half-inch diameter PVC pipe
e) may be used.
f) Inside the pit: Bamboo made vermicomposting tank and Wash collection tank
g) should be laid with Black polythene sheet (Best Quality)
h) The bottom should have a mild slope towards the Wash collection tank.
i) A layer of fine pebble and layer of sand should be placed over the plastic sheet
j) in the vermicomposting tank.
k) The vermicomposting tank should be filled with Semi-decomposed
l) (pre-decomposed) and subsequently, earthworm of proven species is to be
m) released. The dried cow dung should be free of local earthworm species.
n) i. A side drain may be laid out around the vermicomposting unit to prevent ant problem**.**

Size of each tank	: 0.91m (B) x 0.91m (D) x 2.5m (L)
Annual Production capacity	: 900 Kg/ one cycle x 3 cycle = 2700 Kg
Duration of each cycle	: 3 months during summer and 4 months during winter
Duration of the structure	: 3 years

ANNEXURE - I

Bioformulation of Assam Agricultural University, Jorhat with target pests and diseases

Name of formulation	Biocontrol agent	Target pests/diseases
diseases		
a. Solid formulation		
Biofor-Pf-2	*Pseudomonas fluorescens* and *Trichoderma harzianum*	Fungal and bacterial soil borne plant pathogen
Biozin-PTB	*Pseudomonas fluorescens, Trichoderma viride,*	Fungal plant pathogen like
Bio-Llium	*Verticillium lecannii*	Nematodes, whitefly, thrips, mites, aphids, jassids, ants
Bio-Meta	*Metarhizium anisopliae*	Red ants, termites, mosquito larvae, planthoppers, cattle ticks
Bio-Sona	*Beauveria bassiana*	Rice hispa, *Helicoverpa*, white fly, mites, coffee borer, BLB, Bacterial leaf streak of rice
Bioveer	*Trichoderma viride*	Bacterial and fungal wilt, anthracnose, root and stem rots
Biogreen-5	*Beauveria bassiana, Metarhizium anisopliae, Pseudomonas fluorescens, Trichoderma viride* and *Bacillus thuringiensis*	Rhizome rot and wilt of ginger & turmeric, wilt disease of tomato & chilli, Tea mosquito bug, tea looper, red spider mites, stemborer, rice hispa, BLB
Biotime	*Metarhizium anisopliae, Pseudomonas fluorescens* and *Trichoderma viride*	Bacterial and fungal wilt, anthracnose, root and stem rots, diseases of tea, Red ants, Termites, coconut leaf beetle, stem borer, leaf folder

Biozium	*Trichoderma harzianum*	Bacterial and fungal wilt, anthracnose, root and stem rots
b. Liquid formulation		
Org-Metajal	*Metarhizium anisopliae*	Termite, aphid , scale insect Also act as endophyte and give induced resistance
Org-Trichojal	*Trichoderma harzianum*	Soil borne plant pathogen like *Rhizoctonia solani, Sclerotium rolfsii*, *Sclerotinia sclerotiorum*, *Fusarium*, etc. Also act as plant growth enhancer
Org-Vertijal	*Verticillium leccanii*	Red spider mite, Scale insect
Org-Beauverijal	*Beauveria bassiana*	Rice hispa, Tea Mosquito bug, Fusarium etc.
Org-Cilliumjal	*Purpurocillium lilacinus*	Root knot nematode
Org-Pochojal	*Pochonia chlamydosporia*	Root Knot nematode
Org-Metahim	*Metarhizium anisopliae*	Termite, aphid, scale insect

ANNEXURE - II

Organic product as soil enricher

Crop	Type/Nature of the product	Dose and time of application
Rice	Soil enricher / growth enhancer	25 kg (soil application) + 2 sprays @ 2 ml/*l* at pre-flowering and grain setting stage + RDF as equivalent amount from FYM/compost/ vermicompost
Toria	Soil enricher / growth enhancer	25 kg (soil application) + 1spray @ 2 ml/*l* at siliqua setting stage + RDF as equivalent amount from FYM/compost/ vermicompost
Mustard	Soil enricher / growth enhancer	37.5 kg (soil application) + 1 spray @ 2 ml/*l* at siliqua setting stage + RDF as equivalent amount from FYM/compost/ vermicompost

ANNEXUIRE – III

1. AAU Method of Aerobic Composting:

Requirements for Composting:

- Composting Substrates: Rice straw, Azolla, Theprosia, Crotolaria, weed, biomass, Indigofera, Ipomoae, Mikenia, water hyacinth.
- Animal excreta: Fresh cowdung etc. 10-20 kgs in the form of slurry
- Aeration: Bulk substances for faster decomposition.
- C/N Ratio: Maintain 20 : 1 by adding alternate green and brown materials.
- Moisture content: Maintain 50-60%
- Temperature: Maintain 60-65ºC by frequent watering and aerating.
- pH: Maintain 6.5-7.2.
- Use of activator: Use of cellulolytic inoculants to hasten the process.

Method

a) Prepare a pit (3.5 m x 1 m x 0.3 m) and line with polythene.

b) Twigs, prunes and other woody materials are put at the bottom layer.

c) Spread thin layer of green leafy materials over woody material.

d) Again, 10cm thick brown materials like, rice straw, dry leaves, hay, garbage etc are put in it.

e) A thin layer of fresh Azolla is spread over the brown materials.

f) Alternate green and brown materials are spread to maintain optimum C/N ratio.

g) Cowdung slurry is sprinkled over the brown materials.

h) Spread a thin layer of fresh Azolla over the brown materials.

i) Make a 6 feet heap by alternate layering of green and brown materials.

j) The heap is cured for 2-3 months. Occasionally, sprinkle water and turn over the materials.

k) Conversion of entire heap in the compost indicated by change in colour to brown or black.

l) The composted materials is collected and spread over polythene sheet for one month curing.

m) Enrich the matured product further by addition of ingredients as mentioned below.

Additives

- Rock Phosphate (10% P)
- Azolla compost (5 %)
- Compost wash (10%)
- Azolla wash (10%)
- Beneficial microbes @ 1%

  Azospirillum, PSB & *Azotobacter* (Biofertilizer agent)

  Pseudomonas fluorescens (PGPR)

  Trichoderma viride (Biocontrol agent)

n) The compost is then ready for use.

2. Method of *Azolla caroliniana* Cultivation

A low-cost rapid multiplication method of *Azolla caroliniana* developed in the Soil Microbiology & Biofertilizer Laboratory, AAU, Jorhat as follows:

- Dig out a pit in the ground of size 2 m x 1 m x 0.20 m and level
- Place good quality polythene to cover the pit
- Raise the bund through mud plastering all around the pit
- Maintain water level at 10-20 cm
- Add 10 g each of SSP, MOP & Zn Sulphate plus 200 g of dried powdered cowdung
- Apply 300-400 g of fresh *A. caroliniana* in the pit
- Multiply Azolla for 15 – 20 days until a thick Azolla mat is formed and by this time there will be increase in fresh biomass to the tune of 8 -10 times.
- For continuous harvest of fresh Azolla, 10-15 numbers of the above sized pits are required
- The maximum cost of each pit is approximately Rs. 80-90 and can be used for two years.

3. Preparation of Bordeaux mixture and Bordeaux paste

Bordeaux mixture and Bordeaux paste are broadly used fungicides discovered by Professor Millardet of Bordeaux University, France discovered Bordeaux mixture in 1882.

Required Ingredients for preparation of Bordeaux mixture: (For 1 % solution)

Copper sulphate ($CuSO_4\,5H_2O$): 10 g

Quick lime ($CaCO_3$): 10 g

Water: 1 liter

Procedures for preparation of Bordeaux mixture:

STEP I: Preparation of solution A

i. Weigh copper sulphate and grind to powder form.
ii. Dissolve the copper sulphate powder in 500 ml water.
iii. Strain it through muslin cloth.

STEP 2: Preparation of solution B

i. Grind the weighed quick lime (unslaked lime).
ii. Slake the lime by putting 500 ml water drop wise on it.
iii. Strain it through muslin cloth.

STEP 3: Pour the solution A and B simultaneously into a third container and mix it thoroughly.

Test Methods of Mixture:

It is desirable to test the presence of free copper in the prepared mixture. Since, the free copper in the Bordeaux mixture causes a phytotoxic effect on the sprayed plants. Hence, it should be tested before spraying as follows:

1. Take a clean sharp blade or knife and dip into the mixture for 2 – 3 minutes. If the sharp silver edge of the knife is coated with copper colour, add 1 – 2 g lime.
2. Dip a blue litmus paper in the mixture. If the litmus paper turns red, add more lime to make the solution alkaline till the deposition of copper colour appear on the edge of the knife stops.
3. Add a few drops of potassium ferrocyanide 10% solution into a small quantity of prepared mixture. Reddish – brown precipitation indicates the requirement of extra lime.

Precautions:

1. Use only plastic or glass containers for preparing this solution, as the mixture has corroding action on the metallic containers.
2. Spray the solution immediately after preparation, since it cannot be stored.
3. Restrict its spray on fruit crops, *viz.* Apple , Peach, since it causes phyto-toxicity .

BORDEAUX PASTE:

Following ingredients should be mixed thoroughly to form a paste:

Copper sulphate = 20 g

Quick lime = 30 g

Clean water = 300 ml

4. Preparation of plant extract other products for organic plant protection

A. Neem leaf extract

- Immerse 5 kg of fresh neem leaves in 6 liters of water, the leaves are chopped and made into paste, soak in equal amounts of water or cow urine and keep it undisturbed overnight.
- In the morning for better effect, boil the extract for ½ - 1 hour at 70 – 80ºC in a closed container. After boiling, leave it to cool, the cooled suspension must be filtered with muslin cloth and filtrate is stored in a glass bottle and it can be stored up to 15 days. For application, add 150 g of soap powder to the mixture, and spray with 60 liters of water.

B. Neem leaf powder

- Collect fresh neem leaves, clean well to ensure free of dirt and dusts, and dry it in shade for 15 days. Then, crush the leaves to powder form and treat the seeds.

C. Neem seed Kernel extract

- Neem seed kernels are collected, washed & cleaned in pure water and shade dried for a few days. The outer rind of seed is broken and kernels gathered and ground well as paste form and 200 liters of water and 150 ml of soap solution are added and kept undisturbed overnight, filter and spray in the morning.
- Mix paste of neem seed kernel with 5 liters of water or cow urine and leave it undisturbed overnight. The soaked solution must be boiled for 2 – 3 hours at 70 – 80°C. The colour of the solution will turn dark and allow it to cool, filter and store the extract in a clean glass stoppered bottle.
- Neem seed Kernel is soaked in kerosene for overnight. In the next day morning, the suspension is filtered and sprayed by adding a sufficient quantity of water.

D. Neem seed Kernel powder

- Collect neem fruits locally, remove the outer skin along with the pulp, clean the seeds and dry in shade. After a week, remove the seed coat and grind the resultant contents

into fine powder. Sieve it and preserve it for further use.

E. Tulsi / Basil extract

- 300 g of fresh leaves is grinded and put in 2 liters of water
- The solution is now boiled to reduce the solution to 1 liter
- The extract is now filtered and mixed with 10 liters of water and can be used against red spider mite, leaf miner and fruit fly.

F. Chilli extract

- 500 g of fresh chillies is grinded and put it into 3 liters of water and boil the solution for 15 to 20 minutes.
- The solution is now filtered and the clean solution is to be mixed again with 10 liters of water.
- The extract is effective against aphids, whiteflies, diamondback moth ants etc.

G. Garlic extract

- 500 g of garlic is grinded and put it into 8 liters of water.
- The solution is now kept for 2 to 3 days before spraying.
- After that, the solution is filtered to get clean liquid and it is very effective against sucking pests(aphids, jassids, whiteflies etc.)
- For most of the natural sprays, it is necessary to spray every 3 to 5 days until the problem has finished.

H. Garlic clove extract

- Chop clean garlic bulbs, make them into paste and soak with equal volume of kerosene and allow the mixture to stand still for overnight. Mix it and filter with fine Muslin cloth. Add 150 g of soap powder to the mixture and store in a clean glass bottle for further use.

I. Cow dung extract

- Collect fresh cow dung, dissolve it at the rate of 100 g keep in 100 ml of water, keep overnight. Filter it through muslin cloth. Dilute by adding 10 liters of water and spray in the evening hours. It will cure the bacterial leaf blight disease of rice.