TRAINING MANUAL

FARMERS TRAINING

DIRECTORATE OF AGRICULTURE

MEGHALAYA, SHILLONG.

Foreword

To address to the need for successful implementation of the scheme on "Farmers Training Institute", the Directorate have developed the training manual to address to the training need assessment, in order to impart systematic, effective and uniform trainings on the subjects dealing with specific crops relating to specific locations, to the farmers of the State for implementation.

The manual per se is designed to provide technical knowhow to the farmers with the sole aim to step up the level of production and productivity through integrated development of Agriculture and to subsequently upscale the agrarian economy of the State.

The department is confident that the participants in the training will benefit immensely from this exercise and acquire the knowledge intended for achieving the purpose of the scheme.

Shri. R. Langstieh

Director (Research &Training)

Meghalaya::Shillong

CONTENTS

1. Introduction:-

Training is an important tool for assisting the development departments in achieving the programme objectives and effective implementation of plan. Training operates in the domain of knowledge, skills, attitudes and providing experience. Training is a complex activity which requires preparation, planning and execution. The designing of training is an important factor which requires knowledge on the need of the farming community, knowledge on the subject and competence in the training process. Training provides solution to a number of problems faced by the farming communities in their day to day activities. Addressing such problem will bring about beneficial solution which in turn helps the farming communities in uplifting their socio-economics status.

Objectives:-

1. To create awareness amongst the farming community about the latest developments in the field of agriculture and horticulture.
2. To enable the farmers to acquire new skills and also improve their old skills.
3. To train, educate and equip the farmers with improved technologies including use of high yielding varieties of seeds, timely sowing, intercropping, crop rotation integrated pest management, nutrient & soil management, different composting and post-harvest management in village level, block level and institutional level.
4. To make the farmers aware about the importance and uses of Bio-fertilizers, Bio-pesticides and Bio-Agents.
5. To demonstrate the advantages of using Bio-fertilizers, Bio-pesticides and Bio-agents through field demonstrations.
6. To give confidence to the farmers that a particular recommended practice is a practicable proposition in their own situation through demonstrations and hands-on.
7. To uplift the socio-economic status of the farmers through his adoption of improved technologies provided through training.

2. Module of the Trainings for 2018-19

MODULE - 1

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Tuber Crop (Potato)	64
4	1 pm – 2 pm	Cultivation of Vegetables: Cole crops	22
		Legumes	27,59
		Root crop	5,16,66
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Cultivation of high value / low volume vegetables (Capsicum, etc.)	13
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE - 2

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Organic Cultivation of Paddy (Modified SRI)	56
4	1 pm – 2 pm	Cultivation of Tuber Crop (Potato)	64
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Cultivation of Vegetables: Cole crops	22
		Legumes,	27,59
		Root crop	05,16,66
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE - 3

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Multiplication & Propagation of Fruit Plants (Plum, Pear, Peach etc.)	62, 60
4	1 pm – 2 pm	Organic Cultivation of High value Fruits (Kiwi, Strawberry, etc.)	39, 71
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Orchard Management	52
7.	4 pm – 5 pm	Integrated Pest Management in Fruit Crops	35

MODULE - 4

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Paddy (Modified SRI)	56
4	1 pm – 2 pm	Cultivation of Vegetables: Cole crops	22
		Legumes,	27,59
		Root crop	05,16,66
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Organic Cultivation of Maize	43
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE - 5

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Tuber Crop (Potato)	64
4	1 pm – 2 pm	Organic Cultivation of Maize	43
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Cultivation of Vegetables: Cole crops	22
		Legumes,	27,59
		Root crop	05,16,66
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE - 6

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Tuber Crop (Potato)	64
4	1 pm – 2 pm	Organic Cultivation of Tomato	75
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Cultivation of Vegetables: Cole crops	22
		Legumes,	27,59
		Root crop	05,16,66
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE - 7

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Tuber Crop (Potato)	64
4	1 pm – 2 pm	Cultivation of Paddy (Modified SRI)	56
5.	2 pm - 3 pm	Break	
6.	3 pm – 4 pm	Cultivation of Vegetables: Cole crops	22
		Legumes	27,59
		Root crop	05,16,66
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE - 8

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Tuber Crop (Potato)	64
4	1 pm – 2 pm	Cultivation of Paddy (Modified SRI)	56
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Soyabean Cultivation	70
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE - 9

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Orange Cultivation	51
4	1 pm – 2 pm	Multiplication & Propagation of Fruit Plants (Banana, Plum, Peach, Pear, Strawberry, Kiwi etc.)	02,62,60, 71,39
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Orchard Management	52
7.	4 pm – 5 pm	Integrated Pest Management in Fruit Crops	35

MODULE – 10

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Tuber Crop (Potato)	56
4	1 pm – 2 pm	Cultivation of Paddy (Modified SRI)	64
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Cultivation of Vegetables: Cole crops	22
		Legumes,	27,59
		Root crop	05,16,66
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE – 11

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Tuber Crop (Potato)	56
4	1 pm – 2 pm	Cultivation of Paddy (Modified SRI)	64
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Multiplication & Propagation of Fruit Plants (Banana, Plum, Peach, Pear, Strawberry, Kiwi etc.)	49 (02,62,60, 71, 39)
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE – 12

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Paddy (Modified SRI)	64
4	1 pm – 2 pm	Cultivation of Vegetables (Tomato, Capsicum, etc.)	75,13
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Cultivation of high value / low volume crops (Capsicum, etc.)	13
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE – 13

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 2 pm	Multiplication & Propagation of Fruit Plants (Banana, Plum, Peach, Pear, Strawberry, Kiwi etc.)	02,62,60, 71, 39
4.	2 pm - 3 pm	Break	-
5.	3 pm – 4 pm	Cultivation of Spices (Black pepper, Ginger, Turmeric)	09, 29, 76
6.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE – 14

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54, 81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Arecanut	90
4	1 pm – 2 pm	Cultivation of Betel vine	91
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Cultivation of Spices (Black pepper, Ginger, Turmeric)	09,29, 76
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE – 15

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Organic Farming & Zero Budget Farming	54,81
2.	11 am – 12 pm	Living Soil Concept	42
		Nutrient Management (INM)	34
		Importance of Seed & Soil Testing	69
3.	12 pm - 1 pm	Cultivation of Paddy (Modified SRI)	56
4	1 pm – 2 pm	Cultivation of Spices (Black pepper, Ginger, Turmeric)	09,29, 76
5.	2 pm - 3 pm	Break	-
6.	3 pm – 4 pm	Organic Cultivation of Vegetables (Tomato, Lady's finger, Capsicum, etc.)	75,87,13
7.	4 pm – 5 pm	Integrated Pest Managements	35

MODULE - 16

Sl. No.	Time	Topics	Code No.
1.	10 am - 5 pm	Organic Cultivation of Tea	74

MODULE - 17

Sl. No.	Time	Topics	Code No.
1.	10 am - 5 pm	Mushroom Cultivation	55

MODULE - 18

Sl. No.	Time	Topics	Code No.
1.	10 am - 5 pm	Multiplication & Propagation of Fruit Plants & Orchard Management	49,52

MODULE - 19

Sl. No.	Time	Topics	Code No.
1.	10 am - 5 pm	On Farm production of Trichoderma &Bio control agents	07
		Home Remedies for Management of Insect-Pests and Diseases	93

MODULE – 20

Sl. No.	Time	Topics	Code No.
1.	10 am - 11 am	Theory of different Composting methods (Berkeley Compost, Vermi-compost , Jeevamrit, Panchagavya)	06,78,37,57
2.	11 am – 5 pm	Practical Session on composting	-do-

MODULE - 21

Sl. No.	Time	Topics	Code No.
1.	10 am – 5 pm	Preservation of Fruits & Vegetables	65

MODULE - 22

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	Living soil concept, Importance of soil testing	42,69
3.	12-1pm	Paddy	58
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	Ecological engineering, Organic farming	54
6.	4pm-5pm	Agro Eco System Analysis	99

MODULE - 23

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	IPM in fruit crops	35
3.	12-1pm	Home remedies for disease & pests management	93
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	Organic farming & Zero budget Natural Farming	54,81
6.	4pm-5pm	Preparation of botanical pesticides	98

MODULE - 24

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	Ecological engineering	96
3.	12-1pm	Rodent pests management	97
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	IPM in fruit crops	35
6.	4pm-5pm	Sweet potato	73

MODULE - 25

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	Preparation of botanicals, vermicompost, panchagavya, Jeevamrit	06,78,57,37
3.	12-1pm	BREAK	-
4.	1pm-2pm	Management of orchard	52
5.	2pm-4pm	Sweet potato	73
6.	4pm-5pm	Hand pollination, harvesting and processing of vanilla	101

MODULE - 26

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	Ecological engineering	96
3.	12-1pm	Zero budget natural farming	81
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	Home remedies for management of insect pest and diseases	93
6.	4pm-5pm	Amla and its value addition	102

MODULE - 27

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	Agro Eco System Analysis	99
3.	12pm-1pm	Rodent Pest Management	97
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	Ecological engineering	96
6.	4pm-5pm	Ramie	38

MODULE - 28

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	Hand pollination, harvesting and processing of vanilla	101
3.	12-1pm	Tapioca and its value addition	18
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	Jackfruit and its value addition	36
6.	4pm-5pm	Maize	43

MODULE - 29

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	On farm production of Trichoderma	104
3.	12-1pm	Kitchen garden	38
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	Management of orchard	52
6.	4pm-5pm	Agro Eco System Analysis	99

MODULE - 30

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction/Recap, Discussion of farmers' problems	-
2.	11am-12pm	Ecological engineering	96
3.	12-1pm	Zero budget natural farming	81
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	Jackfruit and its value addition	36
6.	4pm-5pm	IPM in fruit crops	35

MODULE - 31

Sl. No.	Time	Topics	Code No.
1.	10am-11am	Introduction / Recap, Discussion of farmers' problems	-
2.	11am-12pm	Vermicompost, Jeevamrit	78,37
3.	12-1pm	Banana	02
4.	1pm-2pm	BREAK	-
5.	2pm-4pm	Rodent pest management	97
6.	4pm-5pm	Black pepper	09

3. Organic Farming [Code No. – 54]

Organic farming is a crop production method respecting the rules of the nature, targeted to produce nutritive, healthy and pollution-free food. It maximizes and minimises the use off-farm inputs. It is a farming system that seeks to avoid the-use of chemical fertilizers and pesticides. In organic farming the entire ecosystem (plant, animal, soil, water and micro-organism) is protected. The consumers prefer natural/ethnic foods, particularly organic foods across the world and are ready to pay premium price for such foods. The demand for organic agriculture products is on the increase day by day.

It is essential that all the crops in the organic field follow an organic method of production. Though the farmers are free to convert a portion of the farm, it is advisable that the entire farm is converted to organic. However, in the case of large farms, the conversion can be phased out.

The whole farm including the livestock should be converted according to the standard over a period of three years. To ensure a clear separation between organic and conventional production a buffer zone or a natural barrier should be maintained.

National Standards for Organic Crop production

Choice of crops and varieties

All seeds and planting materials should be from crops of organic cultivation. When organic planting materials are not available, chemically untreated conventional planting materials shall be used initially. The use of genetically engineered seeds, pollen, transgenic plants and plant materials is not allowed.

Conversion period

The establishment of an organic management system and building of soil fertility requires an interim period, called as the conversion period. The duration of the conversion period will depend upon.

a. The past use of the land.
b. The ecological situation

The plant products produced annually can be certified organic, when the national standards requirements have been met during a conversion period of at least two years before sowing or in the case of perennial crops other than grassland, at least 3 years before the first harvest of the products. Conversion period can be extended by the certification programme depending on the past use of the land and environmental conditions.

Diversity in crop production

Diversity in crop production is achieved by a combination of:

1. A versatile crop rotation with legumes.
2. An appropriate coverage of the soil during the year of production with diverse plant species.
3. Follow crop rotation for annual crops and intercropping for perennial crops.
4. Avoid crops belonging to the same family in the rotation.
5. Bio fencing with green manure shrubs or neem and other plant protection agents.

Manurial Policy

Sufficient quantities of biodegradable materials of microbial, plant or animal origin should be returned to the soil to increase or at least maintain its fertility and the biological activity within it. Organic material must be the product of organic farms and the farm must become self-sufficient in producing organic material.

Soil fertility should be maintained or enhanced by:

1. Raising green manure crops, leguminous crops.
2. Incorporate crop residues.
3. Use biodegradable materials of microbial, plant or animal origin.
4. Encourage the use of on-farm inputs.
5. Use of synthetic or chemical fertilizers and growth regulators are not permitted.
6. Mineral based materials like rock phosphate, gypsum, lime, etc., in limited quantities and in their natural compositions.
7. Prevent the accumulation of heavy metals and other pollutants.
8. Minimize the nutrient loss by management practices.
9. Apply manures as per soil test result.
10. Maintain adequate pH levels.
11. Manures containing human excreta not be used.

Pests, diseases and weed management

Organic farming systems should be carried out in a way, which ensures that losses from pests, diseases and weeds are minimized. Conditions for minimizing the loss due pest, diseases and weeds are:

1. Balanced manurial programme.
2. Use of crops and varieties well adapted to the environment.
3. Fertile soil of high biological activities.
4. Adopt rotations.
5. Companion planting.
6. Green manuring.
7. Natural enemies of pests and diseases should be protected and encouraged.
8. Cultivate trap crops.

Pest and disease control

1. Prohibit the use of synthetic chemicals.
2. Use preventive cultural techniques.
3. Encourage and protect natural enemies.
4. Use products from local plants and of biological origin prepared at the farm.
5. Prohibit the use of genetically engineered organisms and products.
6. Brand name products must always be evaluated.

Weed control

1. Slash weeding.
2. Thermic weed control.
3. Mechanical weed control.
4. Use weeded materials as mulch.
5. Use clean equipments for organically managed areas.
6. Use of synthetic herbicides, synthetic growth regulators and synthetic dyes are prohibited.

Contamination control

All relevant measures should be taken to minimize contamination from outside and within the farm. Accumulation of heavy metals and other pollutants should be limited. Cultivation has to be guarded against the possibility of pesticide and weedicide contamination and the carriage of inorganic chemicals used as fertilizers by irrigation and drainage. For protected structure coverings, plastic mulches, fleeces, insect netting and silage rapping, only products based on polyethylene and, polypropylene or other polycarbonates based materials are allowed. These shall be removed from

the soil after use and shall not be burnt on the farm land. The use of polychloride based product is prohibited.

Soil and water conservation

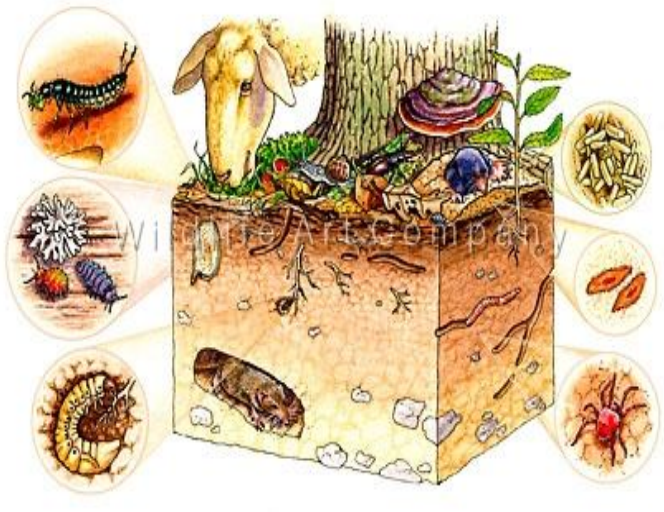
Soil and water resources should be handled in a sustainable manner. Relevant measures should be taken to prevent erosion, salination of soil, excessive and improper use of water and the pollution of ground and surface water. In sloppy lands, adequate precautions should be taken to avoid the entry of run-off water and drift from the neighbouring farms. Clearing land through the means of burning organic matter shall be restricted to the minimum. The clearing of primary forest is prohibited.

Food Processing and Handling

Storage, transportation, processing and labelling

Pests at the storage and processing stage must be controlled by means of physical barriers, sound and light, with temperature and atmospheric control. Mixture of organic and non-organic products must be prevented during processing. Additives and substances that diminish or alter the nature of organic produce are to be avoided. Irradiation is not allowed. Processing methods should be based on mechanical, physical and biological process. Packaging must take care to prevent material contact to diminish the organic purity of the produce. Eco- friendly, bio-degradable materials should be preferred media of packing. Waste generating packaging and pollution causing packing and materials are discouraged. Labelling shall convey clear and accurate information on the organic status of the product. The label for organic products should be clearly distinguishable from the label for conventional products. The labelling of organic produce must declare openly the fact of totally organic or under conversion period. The practice of organic farming is found to be compatible with the preservation and improvement of the environment.

4. Living Soil Concept [Code No. – 42]

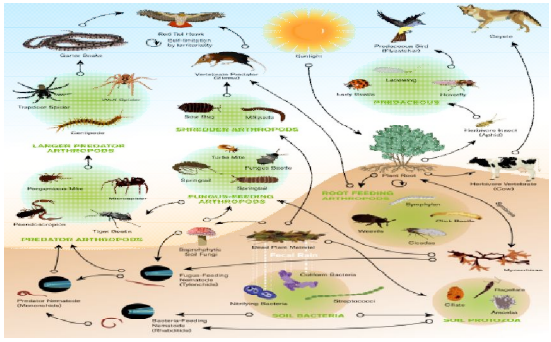


Causes and Effects of Soil Degradation

Over the last 50-60 years, for boosting crop production, indiscriminate use of chemical fertilizers, pesticides, monoculture, heavy tillage, etc. are promoted. Non judicious use of inputs led some adverse effect on our environment including soil ecosystem. Disturbance in natural soil system has made the soil unproductive on long term basis.

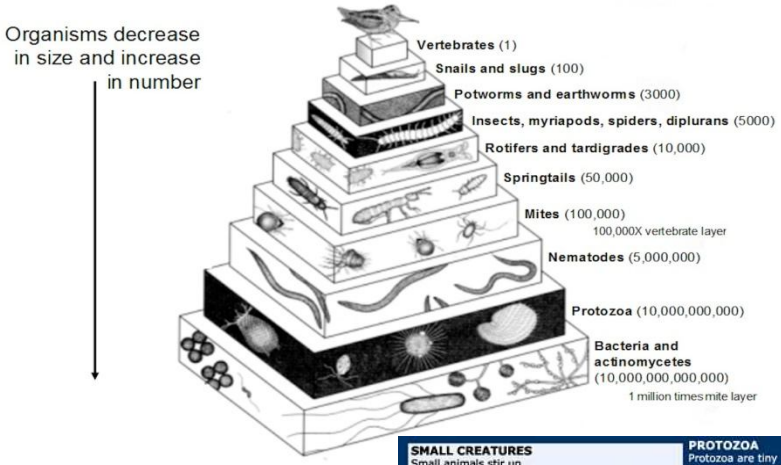
"All soils everywhere are comprised of the same basic critter groups. What's different about a desert, the tundra, a rainforest or a cornfield are numbers (relative densities of critters)." The concept that ties the different groups together is the soil food web.

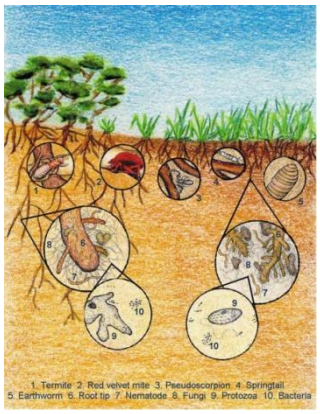
Soil Food Web: Eat and be Eaten

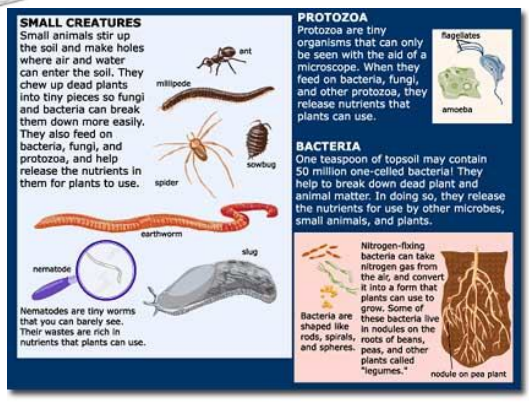


- *Life on earth is sustained by a complex underground ecological system - the soil food web.*
- *Through ignorance, food web is disrupted , in particular with ill-advised farming methods.*
- *We can return the food web to health by restoring the soil biology.*
- *The principle of 'living soil' is that*
- *Soil seems dead and inert material but is quite alive*
- *Instead of trying to feed the plant directly, the objective should be to nourish the soil.*

In one square meter of soil....







For this, the agriculture system has to be based on local resources, farmers' knowledge, management skills and labor.

SOIL BIOTA

- *Bacteria chemical factories, convert wastes to nutrients*
- *Fungi convert woody substances to digestible compounds*
- *Amoebae prey on bacteria and fungi*
- *Nematodes hunt on amoebae, attack roots, eat fungi*
- *Arthropods (insects, collembolans, mites, etc) eat all of above*
- *Earthworms eat soil & leaf litter, drillospheres, bury litter*
- *Higher predators burrowing animals, reptiles*
- *Plants roots exude organic compounds- proteins, sugars and carbohydrates ("cakes and cookies") which attract beneficial micro-organisms.*

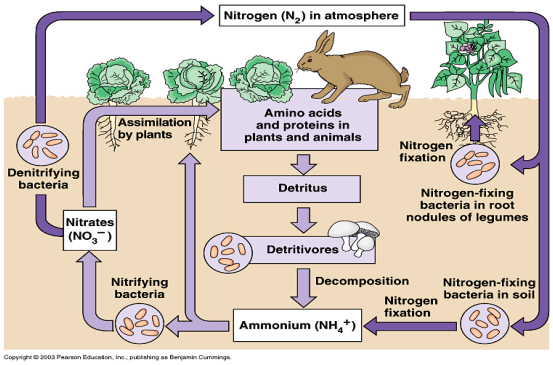
Figure 07_16

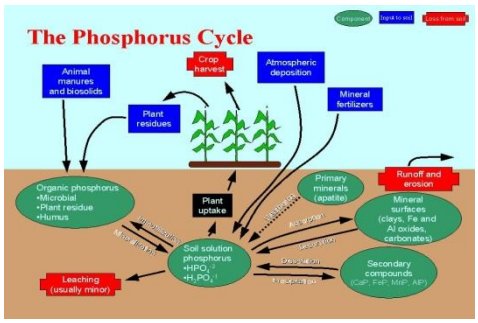
Functions of soil organisms

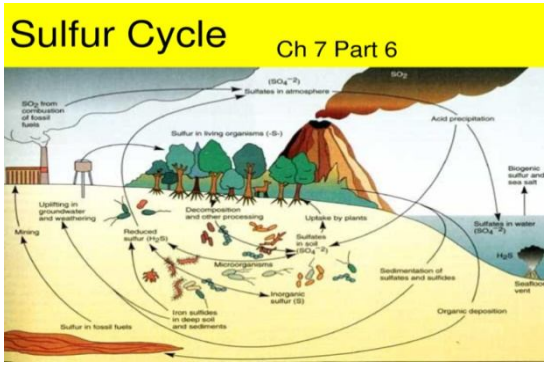
Soil organisms support plant health as they;

- Decompose organic matter,
- Cycle nutrients,
- Enhance soil structure,
- Control the populations of soil organisms including crop pests.
- Can tie up salts and harmful chemicals.
- Provides adaptation to changing conditions.

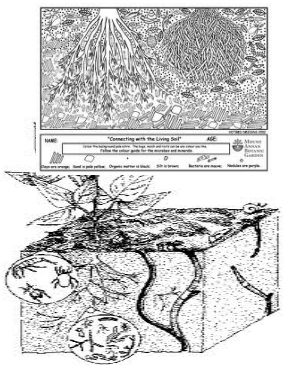
Soil life–involvement in plant nutrition

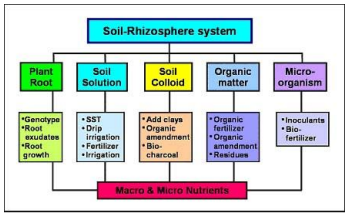


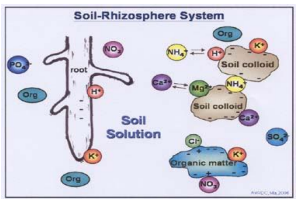




Soil Rhizosphere- habitat for soil life







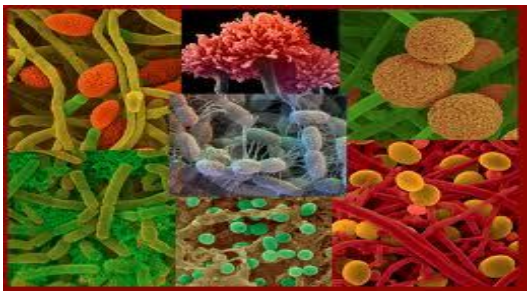
THE LIVING SOIL:

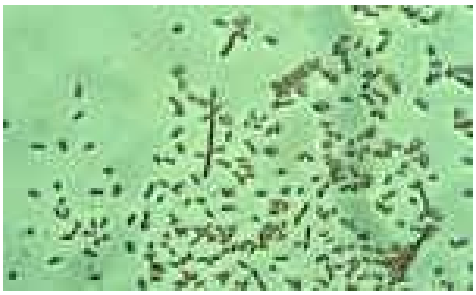
Bacteria

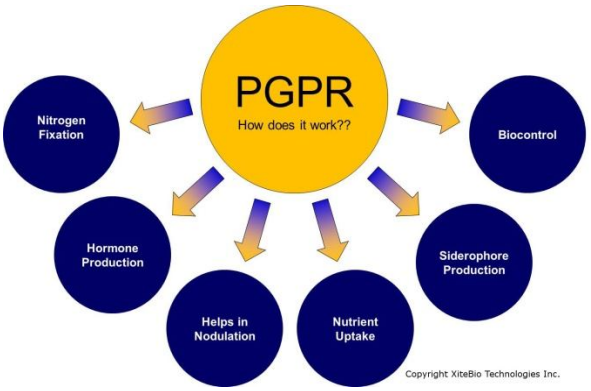
The bacteria and fungi attracted to the roots are "the white knights fighting off the bad guys."

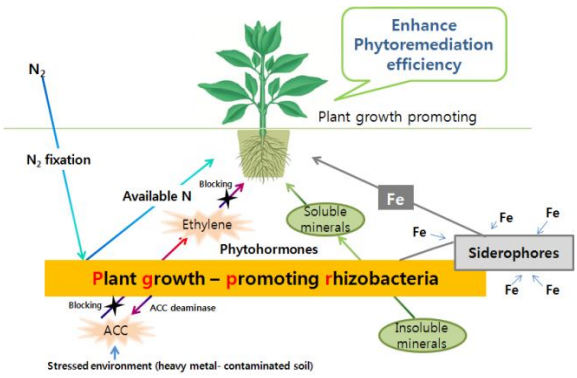
A ton of microscopic bacteria may be active in each acre of soil.

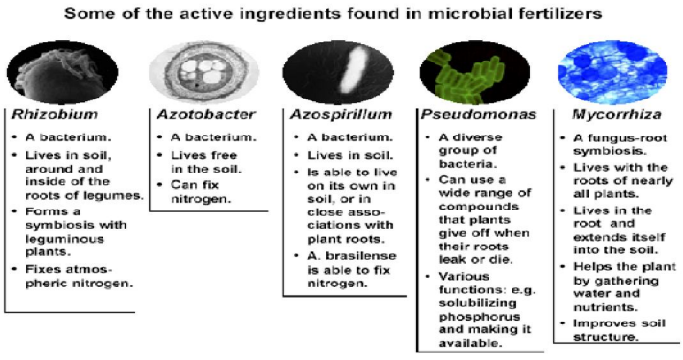
Bacteria dot the surface of strands of fungal hyphae

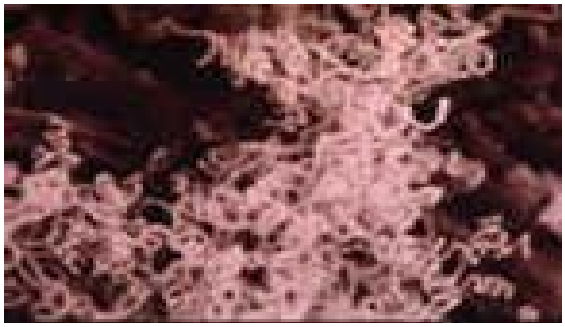


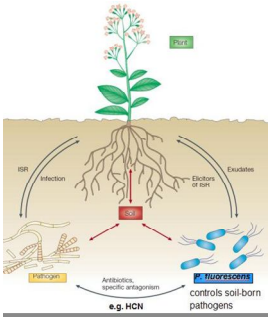


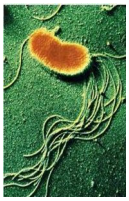












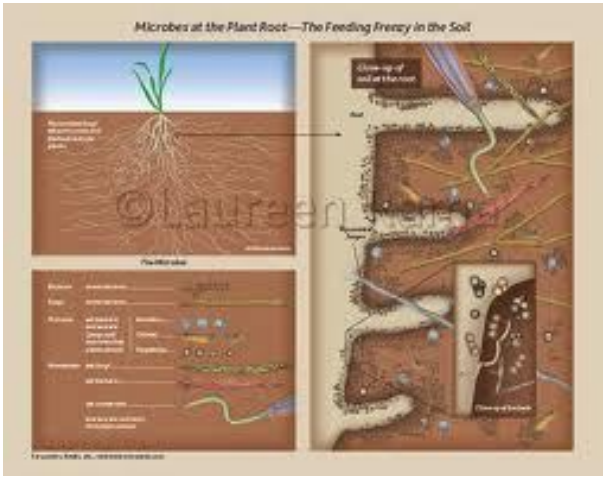
Soil beneficial *Pseudomonas fluorescens.*

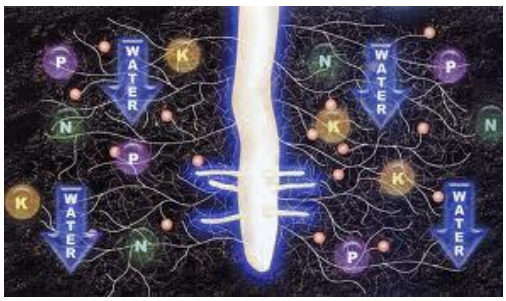
Soil beneficial *Pseudomonas fluorescens.*

- Siderophores (meaning "iron carrier") are small, high-affinity iron chelating compounds secreted by microorganisms such as bacteria and fungi, and also grasses.
- Siderophores are amongst the strongest soluble Fe3+ binding agents known.
    - e.g. *P. fluorescens*, *Bacillus*.

THE LIVING SOIL:

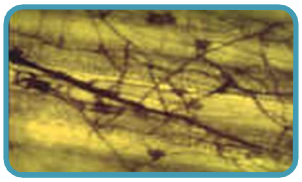
Fungi





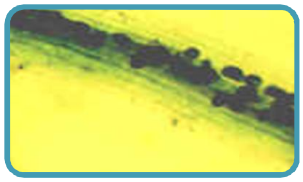
Fungi Play important functions in soil

Tree roots (brown) are connected to the symbiotic mycorhizal structure **(bright white)** and fungal hyphae (thin white strands) radiating into the soil.



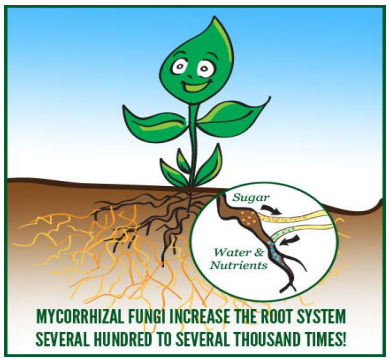
Fungus beginning to decompose leaf veins in grass clippings.

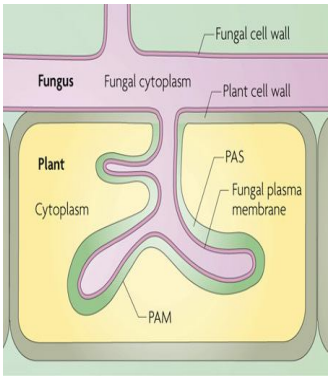
Ectomycorhizae are important for nutrient absorption by tree and grape roots.

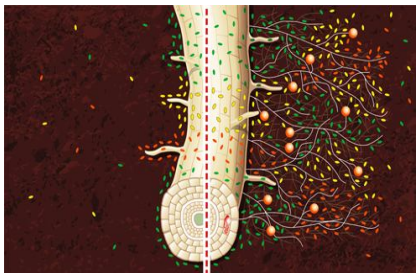


Endomycorhizae arbuscular mycorhizal fungus (AM).

Mycorrhizae: Give and Take Relationship



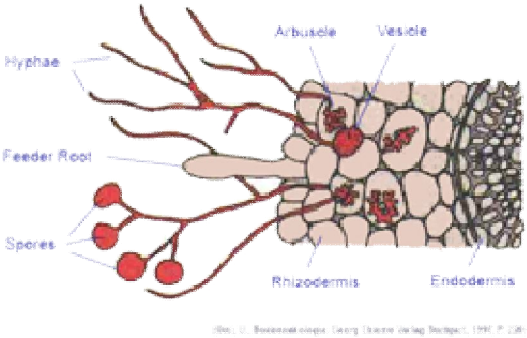


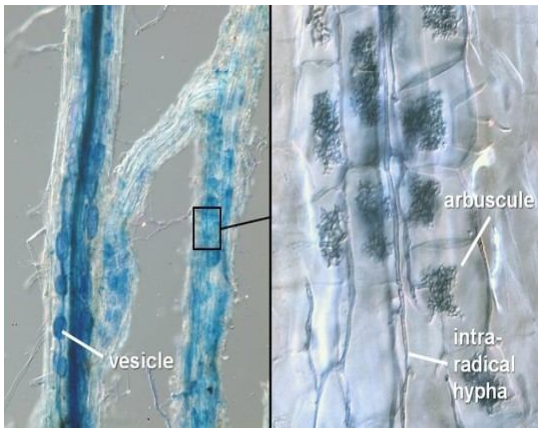


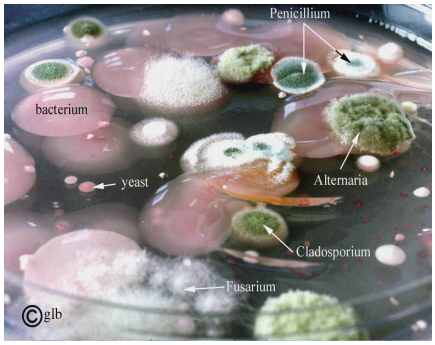
VAM Fungi

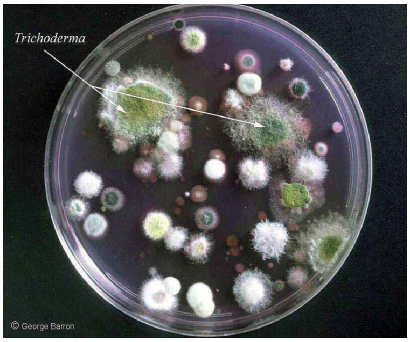
Symbiotic Fungus:

Wheels within wheels... life within life. Feeder root of a plant containing the nutrient-absorbing parts (dark blue) of a symbiotic fungus. Vesicular-arbuscular mycorrhizae ("VAM") fungi like this one colonize the root systems of most plants, providing nutrients and water to the plants, as well as protection against parasitic nematodes and root rot fungi.



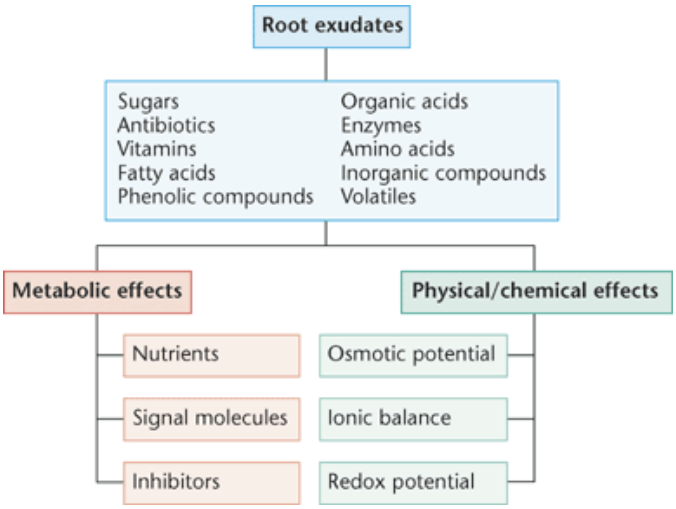






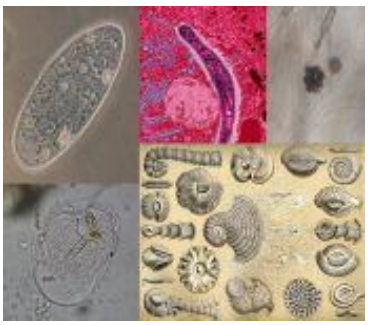
Soil contains large numbers of microorganisms - measured in hundreds of thousands per gram of soil. In this petri dish there is an equivalent of 1/1000 of a gram of soil.

Diverse compounds exuded by different parts of the root system create a unique environment known as the rhizosphere. Interactions among microorganisms found within the rhizosphere and communication between these microorganisms and plant roots play an important role in maintaining plant health.



THE LIVING SOIL:

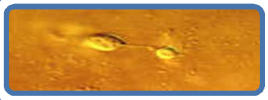
Protozoa



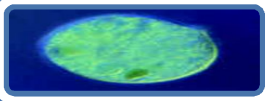
Role of protozoa in nutrient recycling

Protozoa play an important role in **nutrient cycling** by feeding intensively on bacteria. Notice the size of the speck-like bacteria next to the oval protozoa and large, angular sand particle

Bacteria ingested by an amoeba.



Flagellates have one or two flagella which they use to propel or pull their way through soil. A flagellum can be seen extending from the protozoan on the left. The tiny specks are bacteria.



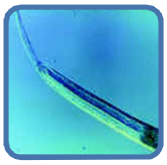
Ciliates are the largest of the protozoa and the least numerous. They consume up to 10,000 bacteria per day, and release plant available nitrogen. Ciliates use the fine cilia along their bodies like oars to move rapidly through soil.

THE LIVING SOIL:

Nematodes

Most nematodes in the soil are not plant parasites.

Beneficial nematodes help control disease and cycle nutrients.



A predatory nematode consumes a smaller nematode

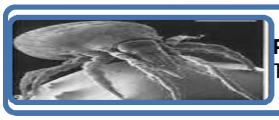
Broadly, there are four groups of nematodes

1. Predatory nematodes
2. Root feeders
3. Bacterial feeder
4. Fungal feeder

THE LIVING SOIL:

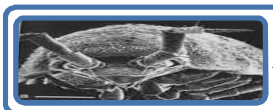
Arthropods

The 200 species of mites in this microscope view were extracted from one square foot of the top two inches of forest litter and soil.
Mites are poorly studied, but enormously significant for nutrient release in the soil.



Predatory mites prey on nematodes, springtails, other mites, and the larvae of insects. This mite is 1/25 of an inch (1mm) long. *Pergamasus sp.*

Millipedes are also called Diplopods because they possess two pairs of legs on each body segment. They are generally harmless to people, but most millipedes protect themselves from predators by spraying an offensive odor from their skunk glands.



Sow bugs are relatives of crabs and lobsters. Their powerful mouth-parts are used to fragment plant residue and leaf litter.

Giant Red Velvet Mite (*Trombidium grandissimum*)

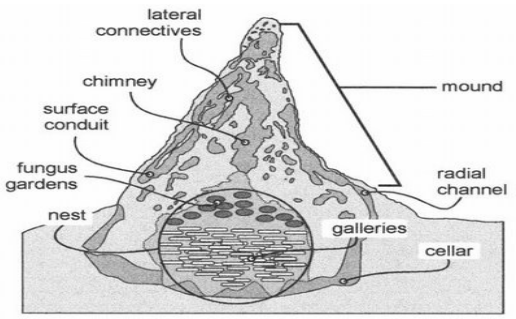
Since the Giant Red Velvet Mite spends the majority of its life in the soil, it lives in close proximity to bacteria, nematodes, and fungi-not to mention other insects and spiders.

As the diet of the Giant Red Velvet Mite consists of many pests, the mite could be used as a potential biological control tool.

Soil Arthropods : Termites

Termites are notorious for their voracious appetite for lignocelluloses i.e. timber, wood, cotton, jute and paper etc. causing damages more than earthquake and fire.

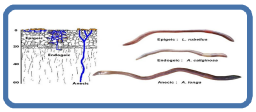
Termites are important in rehabilitations of degraded soil, survival of forest by recycling nutrients taken from soil by trees and plants



Termite mounds and plant growth

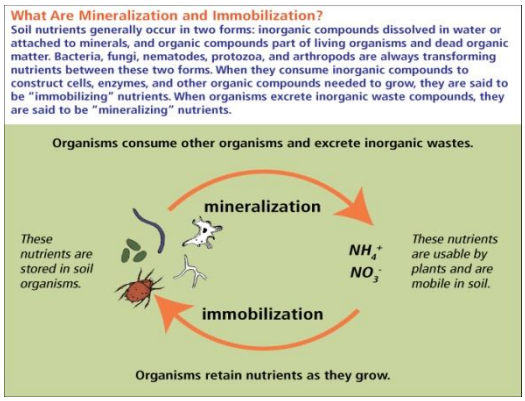
Earthworms

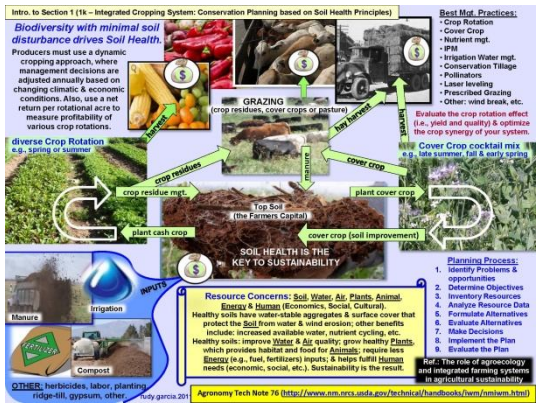
Earthworms generate tons of casts per acre each year, dramatically altering soil structure



Some worms live in permanent vertical burrows

Others move horizontally near the surface, filling their burrow with casts as they move.





5. Importance of Soil Testing & Seed Testing [Code No. – 69]

Soil Testing

Every area is different when it comes to soil types and nutrient contents in soil. Soil sampling and testing can show you the plant available nutrients and other soil chemical factors important for plants.

Nutrient levels in soil also vary from year to yes, so it is important to perform soil sampling and testing prior to planting any new crop. It is important for farmers to follow certain recommended steps for soil sampling and testing to develop a fertility management program.

To ensure accurate results, standards must be set for performing soil sampling and testing. Here are some of the guidelines:

1. Begin by evaluating each field to determine representative areas.
2. Major areas within fields that have distinctly different soil properties, such as texture, should be sampled and fertilized as separate fields because of the potential for different nutrient requirements.
3. Samples should be taken at 0.6, 6 to 12, and 12 to 24 inch depths from) 5 to 20 locations within each field.
4. Each depth should be bulked into composite samples, air dried, and sent to a reputable soil testing lab.

FIVE REASONS WHY SOIL TESTING IS IMPORTANT TO FARMERS

1. Farmers will know the current condition of their soil and how to improve it.

Soil fertility is determined by the soil's chemical, physical and biological properties. Properties such as soil texture, colour and structure are visible to the eye. However you can't see the chemical composition of soil. Therefore it needs to be measured. That is why soil sampling is essential. Soil tests are used to determine the soil's nutrient content and pH level. With this information you can define the exact type and quantity of fertilizer needed to be applied to improve your soil. This is important because fertile soils are necessary to grow healthy crops.

2. Farmers can minimise fertilizer expenditure

Knowing the exact type and quantity of fertilizers your soil and crops need prevents you from wasting money on unnecessary fertilizers.

3. With soil testing farmers can avoid over-fertilization

Applying fertilizer without knowing the actual nutrient needs of your soil might lead to over-fertilization. Testing your soil and receiving a fertilizer recommendation prevents applying excessive amount of fertilizer and the related environmental damages. Over-fertilization might result in nutrient leaching, water pollution and irreversible harm to the aquatic animal life. A simple soil test can prevent this negative effect. Furthermore, overuse of fertilizer is harmful not only to the environment but also to the crops as it might cause fertilizer burn.

4. Farmers can avoid soil degradation

It is estimated that each year 24 billion tonnes of fertile soil are lost due to erosion which is a result of unbalanced soil management. Moreover, land degradation directly impacts the health and livelihoods of an estimated 1.5 billion people. Soil restoration is a difficult, costly and time-consuming process. Therefore, proper soil management in the form of soil testing and application of the right fertilizers is more efficient and financially justified.

5. Farmers with fertile soils can contribute to feeding the world's growing population.

Nowadays we put more pressure on our soil than ever before. We need fertile soils to feed the world's rapidly growing population. Improved soil fertility means more crops worldwide, potentially closing the world's food gap. This will bring a better life for millions of people particularly in developing countries. Soil testing is the first step in soil fertility management. Soil testing gives valuable information and helps you improve your soil's health. And healthy soils mean healthy crops!

HOW TO COLLECT SOIL SAMPLE

How to Take a Soil Sample: The reliability of a soil test is only as good as the sample you submit. The small amount of soil in the sample bag you send to the Agricultural Testing Lab must represent the entire area to be fertilized. Avoid unusual areas such as those where fertilizer or lime has spilled. Take samples before lime, fertilizer, or manure are added. Use only clean equipment for collecting soil samples.

Where to sample: The area to be sampled should be as uniform as possible in terms of soil type and cropping and fertilizing history. For practical purposes it should be an area you expect to fertilize as a unit. This means separate samples for annual mixed vegetables and a strawberry patch, for golf green and fairway, and for different major crops in a commercial nursery or vegetable operation. If you have a problem on part of a lawn, garden, or commercial production field, you may wish to determine if soil fertility is the cause by taking one sample to represent the "good" and the other to represent the "poor" area.

Take a good sample: Collect a number of cores or slices by walking in a zig-zag pattern over the area. Mix cores thoroughly in a clean pail for a composite lab sample. The greater the number of collected cores mixed together, the better the sample will represent the average condition of the sampled area. Consider 10 cores as the minimum for home gardens and lawns up to 10,000 square feet in size. Larger areas should be represented by at least 15 to 20 samples.
Choose one of the following tools:

Soil Probe or Auger: A soil probe or auger, available from mail order catalogs and garden or farm supply outlets, is the best tool for sampling. An auger will be needed if the soil is very stony or gravelly. Simply push the probe (or push and turn the auger) into the soil to the desired depth, lift up to remove the core, and place it in the clean pail. Sampling depth should be 4 to 6 inches deep for lawns, turf, or other perennial sod, or tillage depth (usually 6- I 0 inches) for annually tilled crops.

Garden Trowel or Shovel: If a soil probe or auger is not available; collect your sample by pushing the blade of a garden trowel, shovel, or spade into the soil to the desired depth. Cut out a triangular wedge of soil and set it aside (to be replaced after sampling). Now slide your blade into the soil again taking a thin (half inch) slice from one side of the hole. With a knife, trim the slice to about a 1-inch strip of soil down the center of the spade - top to bottom. Save this "core" as part of your composite lab sample.

Mix the sample and fill the sample bag: Make sure that all the cores are thoroughly mixed together. Your soil test mailer contains a plastic bag intended for one lab sample. Fill plastic bag about 112 full (approximately 1 cup) with the mixed sample.

Importance of Seed Testing

The main objective of the Seed Testing is to obtain accurate and reproducible results regarding the purity, composition, moisture content and the percentage of seed that can be expected

to produce normal seedlings under favourable condition. Seed testing and quality control has assumed great importance in seed, programmed to make available to the farmers.
Thus by testing the seed the farmer will be able to get accurate information about quality and reproducibility of the seed before sowing and there-by help in enhancing the yield and minimizes the risk of sowing decayed, damaged and diseased seed which are the factors contributing to low yield / unit area.

HOW TO COLLECT SEED SAMPLE

Seed sampling is selecting a small portion of seed from a larger amount. This sample can be taken in the field, from bulk storage, or from grain stored in sacks. The purpose of seed sampling is to obtain a portion that is representative of the entire seed lot. This means that the characteristics (e.g. moisture content) of the sample are similar to those in the lot from which the sample was taken. When such a sample is analysed, the results are as good as measuring the whole lot.

When selecting samples, equal amounts should be drawn from different parts of the seed lot - from the top, middle and bottom of the lot. In general, seed lots are either in bags, in bulk or in stream. The amount or size of a seed lot determines how much sampling is required. This is called the sampling intensity.

Sampling Intensity

1. **FIELD SAMPLE:** Obtaining a representative sample from a field. A field is usually not uniform - the edge or border rows are different from what is obtained from the middle of the field. In order to get a representative sample:
   i. Walk through the whole field in a pattern.
   ii. Hand-pick and shell grain from several plants.
   iii. Mix the grains you have picked.
   iv. Take at least three readings for an average value.
2. **BAG SAMPLE:** to decide how many bags to sample from, take samples from a number of bags that represents the square root of the lot size. Examples: if the lot contains nine bags, then sample at least three bags (9=3).

   If the lot contains 100 bags, then sample at least 10 bags (100=10).
3. **BIN SAMPLE:** when sampling from a bin, to get a representative samples, collect seeds from various depths and avoid the centre and the corners. Select samples from as many parts as possible within the bulk storage. Do not mix the sample: test them separately. Knowing the properties of the samples at different locations will help in making management decisions.
4. **SEED IN BULK OR IN STREAM**

WEIGHT OF THE LOT	NUMBER OF PRIMARY SAMPLES
Up-to 500	At least 5
501-3000	1 for each 300 kg (but not less than 5)
3001-20,000	1 for each 500 kg (but not less than 10)
More than 20,0001	1 for each 700 kg (but not less than 40)

5. **SEED IN SMALL CONTAINERS:** If a container holds 15 kg or less it may be sampled as for seed bags. Containers of 15kg or less may be combined into units of 100 kg and each unit regarded as one container and then sampled as for bags. If the seed is in small packets, up to 100g, each packet should be considered as a sample. Samples should be taken to give enough seed for the required test.

Handling of samples

Avoid delays in processing the samples because changes in moisture content and quality occur over time.

i. Put samples either in sealed containers or plastic bags immediately after sampling to maintain the current moisture content.
ii. If temporary storage is necessary, store the samples in a refrigerator or a cold room.
iii. Always label the sample containers properly with a permanent pen.

6. Integrated Nutrient Management [Code No. – 34]

Integrated Nutrient Management is the use of different sources of plant nutrients integrated to check nutrient depletion and maintain soil health and crop productivity.
It is a practice where all sources of nutrients namely organic manures, inorganic/chemical fertilizers, bio-fertilizers are supplied as plant nutrients for better utilization of resources and to produce crops with less expenditure.

Mineral Nutrients: These are elements present in the soil which can be absorbed by the plants for its growth and development.

Nutrient Management: The adequate and timely application of essential nutrients by way of application of manures, fertilizers, bio-fertilizers, etc.
List of 16 Essential Nutrients

1. Carbon
2. Hydrogen
3. Oxygen
4. Nitrogen
5. Phosphorous
6. Potassium
7. Calcium
8. Magnesium
9. Sulphur
10. Iron
11. Manganese
12. Zinc
13. Copper
14. Boron
15. Molybdenum
16. Chlorine.

Classification of essential Nutrients based on amount required by plants:

- ✓ Basic Nutrients
- ✓ Macro nutrients
- ✓ Micro nutrients

NUTRIENT MANAGEMENT

The resource components available for nutrient management in organic farming

Green Manure

1. Ploughing or turning down tender and fresh green biomass into the soil, for the purpose of improving fertility and physical condition of the soil.

Crop residues and weed biomass

1. The crop residues can be recycled through direct incorporation, compost making and mulch material.

Hedge row /alley cropping

1. Growing leguminous hedge row species in the boundaries will not only protect the field from outside contaminations but also a very good source of plant nutrients and feed forcattle.
2. The pruning of N fixing hedgerow species can add 20 - 80; 3 – 14 and 8 - 38 kg N, P and K / ha / year, respectively.

Vermicomposting

1. Vermicomposting is a method of preparing enriched compost with the use of earthworms
2. Vermi-wash is a liquid manure obtained from earthworm used in vermicomposting and is used as foliar spray. It contains plant growth hormones like auxin and cytokinin apart from nitrogen, phosphorus, potash and micronutrients.
3. Integrated application of FYM @ 10 t/ha and vermicompost 2.5 t/ha along with 150 kg rock phosphate

Mulching and cover crops

1. Paddy straw, crop residues, grasses, locally available weeds like Eupatorium, Ambrosia etc are widely used as mulching and covering material and improved soil fertility on decomposition.
2. Application of 5 tonnes FYM + 2 tonnes vermicompost + 3 tonnes green manures /
3. weed biomass (Eupatorium / Ambrosia) before 20 days transplanting and 250-300 kg
4. neem cakes during transplanting of rice crop is the best nutrient management options for
5. rice.

Panchagavya

1. This contains all nutrients, microorganisms and plant growth nutrients in large quantity and acts 75 per cent as manure and 25 per cent as pest controller.

How to apply

1. Dilute 1litre of mother solution in 10 litres of water (10 % strength) and use as a foliar spray or 5 – 10 litres per acre in irrigation water

Biofertilizers

Types of biofertilizers

1. Nitrogen biofertilizers eg. Rhizobium (most widely used), *Azotobacter*, *Azospirillum*, BGA, Azolla etc.
2. Phosphate biofertilizers eg. *Bacillus*, *Pseudomonas*, *Aspergillus*, *Trichoderma*, VAM etc.

Application method

Seed treatment

1. Suspend 200 gm each of nitrogen fixing and PSB in 300-400 ml of water and mix thoroughly. Pour this slurry on 10 to 12 kg of seed and mix by hands, till all the seeds are uniformly coated. Dry the treated seeds in shade and sow immediately.

Seedling root dip treatment

1. Suspend 1 to 2 kg each of nitrogen fixing (*Azotobacter* / *Azospirillum*) and PSB into just sufficient quantity of water (5 -10 lit depending upon the quantity of seedlings required to be planted in one acre). • Dip the roots of seedlings in this suspension for 20-30 min before transplanting.

Soil treatment

1. 2-4 kg of *Azotobacter* / *Azospirillum* and 2-4 kg of PSB are required for one acre.
2. Mix two types of biofertilizers (100-200 g) in 2-4 liters of water separately and sprinkle this suspension on two separate heaps of 50-100 kg of compost.
3. Mix the two heaps separately and leave for incubation over-night.
4. After 12 hours, mix the two heaps together.
5. In potato it is to be applied after 20 days of planting or at the time of earthing-up operations.

Use & contribution of NBF

Biofertilizer Contribution Use	Biofertilizer Contribution Use	Biofertilizer Contribution Use
Rhizobium (Symbiotic)	50-100 kg N / ha 10-35% increase in yield	Pea, lentil, black gram, green gram, soybean, ground nut etc.
Azotobacter (Non symbiotic) & *Azospirillum* (Associative)	20-25 kg N / ha 10-15% increase in yield	Wheat, maize, cotton, sorghum, sugarcane, rice, vegetables etc.
BGA or Cyanobacteria	20-30 kg N / ha 10-15% increase in yield	Flooded rice
Azolla (Symbiotic)	30-100 kg N / ha 10-25% increase in yield	Flooded rice

Use of Phosphate BF

Bio fertilizer	Use
PSB (*Bacillus, Pseudomonas, Aspergillus, Penicillium* etc.)	All crop
Mycorrhiza (Glomus, Gigaspora, Endogene etc.)	Forest trees, forage grasses, maize, millets, sorghum, barley

7. Potato *(Solanum tuberosum)* [Code No. – 64]

Family – Solanaceae

Potato is one of the most important food crops in the world. David Scott is reported to be the first to bring the plant to Khasi Hills in the year 1830. However the variety which he brought did not suit the hills here and thus did not survive. From the year 1904 onwards many varieties were imported from England and Scotland and trials were conducted at the Upper Shillong farm. Most varieties failed to perform and were discarded but varieties like up – to – date, Great Scot, Royal Kidney and Karr's pink has not only survived but still play an important role in the rural economy of the Khasi Hills. It has hence been our traditional crop for a little over a century. This intimate and long association of the Potato among the Khasi has actually convinced them that this is a life giving crop in these Hills.

Potato - The organic way

Potato is conventionally grown by use of fertilizers like urea, phosphorous and potash. It is also highly susceptible to blight which is effectively controlled by used of fungicides. Therefore, for potato to be economically viable in an organic system of cultivation, utmost attention is to be given to the crop throughout the growing period. Also, prophylactic measures should be taken at the earliest for any anticipated attack by pests and diseases. After harvest, tubers are to be stored in a dry area free from excess moisture and heat.

Land Preparation

Potato is sensitive to water logging and requires sufficient aeration during its growth period. For this reason the plots should be at a higher level to facilitate drainage. In unavoidable circumstances, land should be prepared in such a way that water logging is avoided. This may be done by digging of micro canals in and around the plots. The land is ploughed to a depth of 30 cm and left for sundrying. The soil should:

- Be friable
- In case of high clay content, sand maybe mixed to increase porosity
- Brought to a fine tilth
- Manures should be applied and mixed with the soil during last ploughing. Bio-fertilizers and other soil nutrient sources should also be applied to enhance overall crop growth (See manuring)

Season of planting

Potatoes can be grown only under such conditions where the temperatures during the growing season are moderately cool. Potato cultivation is taken up in four seasons at various altitudes in the state. The autumn crop is cultivated mainly for commercial purpose whereas winter crop caters to local needs. The four crops are: -

Spring Potato: Cultivated in the rice fields by the farmers of Umsning and Bhoirymbong area under Ri-Bhoi District as a proceeding crop to rice. Planting of potato crop commence from 2nd week of January to 2nd week of February and the crop is harvested within the month of May. No fungicides is required for this crop.

Summer Crop: This is the most common growing season in the East, West Khasi Hills and parts of Jaintia Hills District. This crop is planted from end of February to March. This crop generally escapes the late blight disease. Harvesting of the crop starts from July onwards.

The Autumn Crop: Growing of autumn crop is more challenging because of the late blight and the availability of quality seed. But at the same time it is the most rewarding crop as it commands the highest prices. It is planted between August and September and harvested in November and December when there are no availability of fresh potato in the market.

Winter Crop: This crop covers the smallest area. It is cultivated in the lower altitudes areas of the state in the East and West Garo Hills District. Planting is done by the end of October to November.

Varieties: In recent years, a number of potato varieties have been developed by the Central Potato Research Institute, Shimla, to suit different climate and soil conditions. The following are some of the main varieties.

Kufri Anand: The plants are tall, strong and stand straight. The leaves are brown-green and the flowers are light purple in colour. The tubers are white, long and elliptical. It takes 100-110 days for the crop to be ready for harvesting and the average yield is 35-40 tonnes/ha.

Kufri Swarna: The plants are straight, erect, strong and tall with abundance of dark green leaves. The flowers are white and the tubers are of medium size, white in colour, and turn yellowish after drying. The crop duration in summer is 130-135 days in winter, 100-110 days. Its yield is approximately 48 tonnes/ha. This variety is resistant to early blight and late blight diseases and nematodes.

Kufri Sinduri: The plant are tall, straight and erect with abundance of branches. The leaves are light green in colour and the flowers are red with white spots on the petals. The medium sized tubers are red coloured and round/elliptical in shape. The crop duration is 110-120 days. Yield is around 40 tonnes/ha. This variety is resistant to late or early blight and leaf rot diseases and can be grown even in high temperature regions, with minimal irrigation.

Kufri Jyoti: The plants are tall erect, compact and vigorous with few but thick stems. Tubers are medium to large size, oval with white skin and felt eyes. The crop duration is medium to early maturing (110-130 days).

Kufri Megha: The plants are medium tall, semi-erect, medium compact with green straight stems. The flowers are white. Tubers have white smooth surface and round in shape with shallow eyes. The crop is long duration (140-145 days) with a dormancy period of 10-12 weeks.

Kufri Giriraj: The plant is medium tall, semi erect, medium compact, vigorous with medium thick stems that are coloured at the base. Tubers are white with smooth skin, medium to large in size, oval to oblong with felt eyes. The crop duration is 105-135 days with a dormancy period of 8-9 weeks.

Kufri Himalini: The plant is medium tall, semi erect, semi compact, vigorous, green with purple colour at the base. Tubers are medium in size, oval to oblong, with shallow eyes and a pale yellow flesh. The crop is medium duration (110-120 days).

Planting

1. **Seed Size** - The best seed weight for raising summer and autumn crop is 40 - 50g having about 3 - 4 eyes. But, generally medium size of 25 – 75 g can be used. Seed requirement is 2 - 2.5 ton / ha depending on seed size.
2. **Seed Preparation** - Seed from previous year's harvest should be kept in seed trays or basket or spread out on the floor or on racks in a Store / Godown and exposed to natural diffused light to ensure proper sprouting. Unsprouted and rotten tubers should be sorted out periodically. The sprouted seed tuber should be taken to the fields in trays for planting to minimize sprout damage. Before sowing, the seed may be dried in the sun for a day.

   For obtaining higher yield and preventing infestation of diseases it is recommended to treat the seed by soaking it overnight in Jeevamrit.

3. **Planting time** – The main crop is planted in the first fortnight of March and autumn crop is planted in the last week of August to 1st week of September.
4. **Method of Planting** - Tubers should be planted in furrows made at a distance of 60 cm apart against the slope. However, in narrow terraces it can be reduce to 50 cm. It is important to make furrows and ridges upto to a height of 15 cm against the slope to avoid soil erosion. Plant the tuber seeds at a distance of 20-25 cm depending on seed size. Seed tubers should be properly and immediately covered with soil after planting to prevent drying up of the planting materials.
5. **Weed Control -** The potato crop develops canopy in about 4 weeks after planting and weeds must be controlled by this time to gain competitive advantage for the crop. If the weeds are large, they should be removed before the ridging operations begin. Before earthing up the weeds between the growing plants and at the top of the ridge should be removed by mechanical means. Weeding is done manually.
6. **Earthing up -** The main object of earthing up is to keep the soil loose and destroy weeds. Two or three earthing ups should be done at an interval of 15-20 days. The first earthing-up should be done when the plants are about 15-25 cm high. The second earthing up is often done to cover up the tubers properly.

Manuring

Nutrient requirement of potato crop is high and the application of organic manures and bio-fertilizers is considered essential to obtain economic yields. In light soils and places where organic manures are not easily available, green manuring is beneficial. The optimum dose of bio-fertilizer application varies greatly depending upon the type of product, soil type, soil fertility, climate, crop rotation, variety, length of growing season and moisture supply.

NPK granules are applied @ 20kg / ha. Other bio / organic inputs used are

1. FYM or compost @ 30-35 tons / ha.
2. Bio fertilizers – *Azotobacter* or *Azosrillum* for Nitrogen.
3. Bone meal / Rock Phosphate for phosphorous.
4. Wood ash for potash.
5. Phosphorous Solubilising Bacteria (PSB) for solubilising phosphorous.
6. Bio NPK.
7. Further enrichment of the soil maybe ensured through application of Jeevamrit or vermi wash or panchagavya as per convenience.

Plant protection

Potato crop is infested by a variety of fungal, bacterial and viral diseases. As regards pests, some pests attack the foliage while some attacks the tubers. Many of the diseases in potato are soil/seed borne and so once infected is very difficult to control them. Thus, proper diagnosis and control of pests and diseases is of utmost importance. Some of the pest and their methods of control are:-

1) **Aphids**
    a. Install yellow Sticky Trap.
    b. Spray Helicon -L/Bio Power (*Beauveria Bassiana)* @ 15-16 tsp in 16 litres of water.
2) **Potato tuber moth** –
    a. Plant the tubers at a depth of 10 cm.
    b. Cover all the exposed tuber during earthing up.
    c. Used light traps.
    d. Install Pheromone traps 15 nos./ha.
    e. Remove the infected plants from the field and destroy it.
    f. Do not leave freshly harvested Potato tubers in the open field.
    g. Store the potatoes in shelves spread with saw dust, sand and then cover with 2-3 cm thick layers of chopped leaves of *Lantana Sp.*
    h. Cover the opening of the ventilators of the store room or go-down with wire or nylon net.
3) **White grubs and cut worms**
    a. Timely planting and harvesting of Potato crops.
    b. Spray the crop and drench the soil with Helicon – L or Bio Power (*Beauveria bassiana*) 1tsp in 1 litre water.
    c. Spray Multineem or Nimbicidine 8 tsp in 16 litre water.
    d. Soldier @ 8 tsp in 16 litre water and drench the soil.
    e. Soil drenching with bio pesticide-Metarrhizium @ 5g/l of water.

Diseases

1) **Late blight** – It is a fungal disease affecting the leaves stems and roots. Its symptoms appear in the form of green spots on the leaves, which gradually change into black and brown spots. Some cotton-like growth appears on the underside of the infected leaves. A 2-3 cm long, purple streak appears on the stem of the infected plant and the plant looks thin and weak. The infested potato has brown spots on it and is pink inside.

Management

a. The yearly crop cycle should be adhered to.
b. Disease resistance varieties should be selected (viz. K. Giriraj, K. Girdhani, K. Megha, K. Kanchan, K. Himalini)
c. The field should be subjected to 3-4 deep tillings before sowing so that the soil gets treated by the heat of the sun.
d. Soil should be heaped uniformly along the rows to ensure that the potatoes are not left uncovered to prevent greening of tubers due to Glycoalkaloid.
e. The infected plants are to be taken out and burnt somewhere else and not in the field.

Recommendations

a. Disease resistance varieties should be selected.
b. Tuber treatment with *Trichoderma sp* @ 5g/kg of seeds.
c. Foliar application with *Trichoderma sp* + *Pseudomonas florescence* @ 5g/l of water.

d. FYM treated with *Trichoderma sp* @ 2.5 kg / 100 kg of FYM.

2. Early blight (*Alternaria solani*)

Locally known as ïapiong. This disease infects the leaves and it is more prevalent during summer. The fungus is formed due to excessive wetness in the soil and favourable temperatures. Big dark-brown spots appear on the infected leaves. If preventive measures are not taken up the infection spreads to other parts of the plants which weakened the crop till it gradually dies.

Management

a. Before cultivating, the field should be subjected to 3-4 deep tilling so that the soil is exposed to the heat of the sun.
b. The weeds in the field are converted into green manure which enhances the fertility and immunity of the soil and reduces the chances of infection.
c. Strict adherence to the crop cycle decreases the possibilities of this disease.

Recommendation

a. Spraying of vermiwash or jeevamrit mixed with water in a ratio of 1:13.5 litres protects the crop from fungal infestation.
b. *Trichoderma* @ 10 grams / lit water may be sprayed on the crop.

3. Black scurf (*Rhizctonia solani*)

This disease is caused by a soil borne fungus. It infects different organs of the plant including the eyes of the germinated seed, the stem and the flowers. The leaves of the infected plants become red and brown. Tubers of the infected plants have brown spots on them.

Management

a. Crop cycle should be adhered to.
b. Sesbania or corn is cultivated in the field before potato.

Recommendations

a. Spraying of jeevamrit and *Trichoderma* on the standing crop.

4. **Brown rot** (*Pseudomonas solancearum*)

Brown rot is an organically caused disease and generally occurs in the central Himalayan region. The stem of the infested plant turns brown. The plant bends and falls. The leaves also gradually turn brown and eventually the plant dies. This disease generally spreads through infected seeds. It enters the plant through the roots and destroys the tissues of the plant; consequently the flow of water from the roots to the upper parts of the plant is blocked and the plant withers away. This disease generally occurs in summer and increases with a rise in heat and humidity.

Management

a. Infected potatoes should not be used for seed.
b. The seed should not be cut in order to prevent pathogens from entering and affecting other seeds as well.
c. Sowing should be completed by February and the crop harvested before the beginning of the rains.

Recommendations

a. Before sowing, seeds should be treated with Jeevamrit.

5. **Bacterial wilt**
   a. Crop rotation with rice, wheat and maize should be followed.
   b. Application of *Trichoderma sp* + *Pseudomonas florescence* @ 5g/l of water.

Harvesting-

The time of harvest is very important in potato. The development of tuber continues till the vines dies. The main crop is ready for harvest within 75-120 days of planting depending upon the area, soil type and variety sown. The main crop is ready for harvest when majority of the leaves turn yellowish brown. The crop is harvested 10-15 days after haulms cutting for allowing hardening of skin of potato tubers to prevent disease infection through skin. Harvesting should be carried out on bright sunny days. The tubers may be kept in heap for 15 days in the shade for further hardening of the skin. All the cutted, cracked, bruised, damaged and infected tubers should be removed and rejected.

Process of dehaulming

If the produce of the crop is to be used for seed purposes the process of dehaulming is very important. Towards the beginning of June (for summer crop) depending upon the date of planting crop should get crop duration of 80-90 days before dehaulming. Cut the haulms at the ground level. At this time, the crop also starts maturing. The cut haulms should not be left as such in the field. Ensure that there is no re growth of stems after dehaulming as tender succulent leaves are more attractive to the aphids.

Exposed tubers should be covered with soil immediately after dehaulming. The crop should be harvested 10-15 days after dehaulming. This will allow hardening of the tuber skin and increase shelf life of the potato tuber. The practice of haulm cutting is very important for the seed crop as it prevent disease infection through skin. Dehaulming may be skipped if the produce is to be sold for table purpose.

Storage

Harvested tubers should be kept in a well-ventilated room that is relatively dry and dark. Tubers are best stored in racks made out of bamboo or wood which are above ground level and which allow for air movement in between the tubers. Leaves of *Lantana camera* are chopped in to pieces and spread out on the tubers. This is a prophylactic measure against small mites and insects. Light traps can be used to trap flying insects. Fine nets can be used to cover the tubers.

8. Paddy *(Oryza sativa)* [Code No. – 56]

Paddy is one of the major staple food of the world and it's the most important crop of North Eastern Region. However, productivity in India especially in our state is very low in comparison with other countries of the world.

Package of practices of modified SRI

Land preparation for Paddy Cultivation – The land should be deeply ploughed for 2-3 times at a depth of 6 inches. Ploughing is done by digging up, mixing and over- turning the soil and then harrowing is done to break the soil clods into smaller mass followed by levelling. Later puddling is done to provide a soft soil mass for transplanting. Incorporation of green Azolla should be done to enrich the soil and to supply nutrients to the paddy seedlings later. Generally it takes 3-4 weeks to prepare the field before transplanting. The prepared field should be flooded and remain submerged for at least 2 weeks before transplanting.

Selection of Seed: For Medium and Lowland any improved variety which is of 150 days duration.

Seed requirement: 10-12 kgs seeds for 1 ha.

Seed treatment: Before sowing, the seeds should be soaked in salted water (250 gms salt + 10 lits water) for 10-20 mins. The seed which floats should be discarded and the sunken one should be thoroughly wash with clean water. The seeds should then be treated by soaking overnight in a mixture of *Trichodorma* + *Pseudomonas* @ 5 gms/lit of water. The seed should then be dried in the shade before sowing.

Nursery preparation: For transplanting in one ha, 12 beds of 20 x 4 fts is required. Nursery bed should preferably be within or near the main field for easy transportation. Plastic sheets or used polythene -lined gunny bags should be spread on the shallow raised bed to prevent the roots from growing deep into the soil. Then the media mixture comprising of 70% soil + 20% well decomposed organic manure should be uniformly spread on top of the plastic sheets. The beds may then be drenched with *Trichodorma* + *Pseudomonas* @ 2.5 – 5 gms/1 lits water. On the treated beds, the seed should be thinly spread to avoid overcrowding of seedlings and covered with a thin layer of well decomposed FYM or dry soil (5 cm thick). Water the nursery whenever needed to always keep the soil moist. The nursery should be well fenced and protected. Depending upon the locations, seedlings attain sufficient height for transplanting at 14-20 days. The seedling mats are then lifted carefully and transported to the main field where they are then uprooted carefully and transplanted.

Transplanting

Transplanting should be completed before first forthnight of July in low and mid altitude and before 15th June in high altitude to avoid low temperature stress during flowering. Seedlings age of 14-20 days should be transplanted at a distance of 20 cm x 20 cm spacing, 2.4 cm transplant depth and 2 seedlings/hill. Metallic row marker or premarked rope/bamboo pieces can be used for maintaining accurate spacing while transplanting. By maintaining the line and spacing removal of young weeds can be easily done by a cono-weeder. Uprooting of seedlings should be done such

that it does not disturb or damage the roots. The leaves of seedlings should be clipped off at the tips before transplanting to prevent any infestation.

Organic Nutrient Management

Reclamation of acidic soil by slaked lime application as per the soil test is recommended.

An adequate and timely supply of Nutrients is necessary for obtaining sustainable rice production. Supplementation of organic nutrients sustains the crop productivity and soils condition more than conventional fertilizers. FYM, compost, crop residue, oil cakes, green manuring, inter cropping with legumes and bio fertilizers are the major sources of nutrients. During the last ploughing, we need to apply 5-10 T/ha of FYM or any organic compost. Rock phosphate and bone meal for P and wood ash for K maybe applied. Besides these sources, bio fertilizers and Azolla are also valuable source of organic nutrients.

Methods of application of bio fertilizers

Azospirillum

Seed treatment: Mix the carrier based inoculum 200 gm each of *Azospirillum* + PSB in 800 ml of rice gruel to make slurry, which is sufficient to treat 10 kgs seed. The seed and slurry should be well mixed and shade – dry for 30 mins and sowing should be done within 24 hours.

Seedlings rootdip

Prepare suspension by mixing 1 kg each of *Azospirillum* and PSB in 15-20 lits water. Collect the seedlings, make into bundles and dip their roots for 8-10 hours and transplant immediately.

Suspension can be prepared in a plastic-lined pit in the field itself.

Field application

A mixture of *Azospirillum* and powdered FYM (2:50) kg/ ha is to be taken, kept moist and covered for about 1 week with regular overturning. This is then broadcasted in the main field just before transplanting.

AZOLLA

Azolla @ 500 kgs/ha can be applied as green manure before transplanting. Dual culture with rice seven days after transplanting can also be done. Azolla not only supplies N, but also contributes K, P, Ca, S, Zn and Fe. It also suppress weed growth.

Harvest – Crop grown under this system mature 7 days earlier than normal practice.

Water Management: Rice plant is semi aquatic and has been found to give its best performance under continuous submerge condition. But under this system only a saturated field is required for transplanting of young seedlings, maintaining water level of 0.5 inch is sufficient. A cycle of alternate drying and soaking is practiced for it makes the rice plant hardier with profuse root growth. Thus, they can absorb nutrient and water efficiently and provides resistance against short term droughts.

Inter-culture operations

Submerging is an effective method of controlling annual and perennial weeds. Interculture operations should be done at 15-20, 30-35 and 40-45 DAT with the help of a cono - weeder. Weeding with a cono – weeder also simultaneously move the soil around the plants which benefits its growth.

Harvesting:

Harvesting is done at the yellow ripening stage to avoid shattering loss in the field. It is done when 80% grains is matured.

Post Harvest Management:

The harvested food grains should be stored properly. It is advisable to store in bamboo matted structure or in gunny bags which have been soaked in tobacco solution and dried in shades. Dried Neem or tobacco leaves can be crushed and mixed with stored grain to prevent damage by storage pest.

PESTS

The most important insects affecting Rice crop eco-system in Meghalaya are Stem borers, Leaf folder, Gundhi bug, Army worm, Thrips and Rodents.

Natural enemies

Among the natural enemies, the spider and dragon-fly are most common.

Management

The insect pests of rice can be managed by adopting integrated approach:-

1. Planting should be done in time according to the crop duration.
2. Clipping of leaf tips to prevent pest infestation from nursery to main field.
3. Field sanitation is important to prevent multiplication of the pests.
4. Pull kerosinized rope across plants to dislodge cases of case worm hanging on the plants into water then draining off the water.
5. Placement of branches of Khasi pines *(Pinus khasiana)* etc in the field for repelling insects and it also function as perch for predatory birds.
6. Placement of branches of trees as perch for predatory birds.
7. Spraying of Neem oil or Neembicidine @ 6 tsp / 16 lits water at 10 DAT followed by every 20 days interval.
8. Regular monitoring, collection and destruction of eggs, larva, pupa and adults of different insects.
9. Installation of pheromone trap @ 16-20 traps / ha in a triangular pattern at 60 m distance for trapping adult male of yellow stem borer. This should be retained throughout the crop stage by replacing 3-4 times at 20 days interval.
10. Release of *Trichogramma japonicum* or *T.Chilonis* @ 50,000 per ha at weekly interval for 7-8 times starting from 30 DAT for parasiting eggs of stem borer and leaf-folder respectively.
11. Baffle traps should be installed to trap Gundhi bugs. As both male and female are trapped, care should be taken to destroy and bury the bugs to kill the eggs which may be laid by female bugs.
12. One spray of *Beaureria bassiana* @ 5 gm / lit at boot stage will reduce Gundhi bug population.
13. Yellow sticky traps can be installed.
14. Scarecrow can also be installed to drive off birds etc.
15. Rat traps @ 30 traps / ha starting from panicle initiation stage till harvesting of the crop and lining the field with few indigenous grass (sder) having defensive mechanism prevent from rodents.
16. Installation of light traps in the field would attract and kill the moths of leaf folder, stem borer, BPH, gall fly and rice bug.
17. Utilization of botanical formulations especially neem formulation as it acts as feeding deterrents, growth retardants, oviposition deterrents and reproductive inhibitors.

Diseases – Some of the common diseases in this area are given below:-

1. Blast (*Pyricularia grisea*)

Symtoms

a. This disease affects all the aerial parts of the plants.
b. Spindle-shape spots with dark brown margin and grey centre on leaves.
c. Several spots coalesce and lead to big irregular spots.
d. Nodal infection causes the neck to break and panicle hangs down.
e. If neck is infected the grain development gets affected.

Management

a. Field sanitation and burning of straw and stubbles in the field.
b. Seed treatment with *Pseudomonas flourescens* @ 10g / kg of seed.
c. Stagnate water to a depth of 2.5 cm over an area of 25sq. m. in the nursery. Sprinkle 2.5 kg of *Pseudomonas fluorescens* and mix in the stagnated water. Soak the root system of seedlings for 30 min and transplant.
d. Spraying with *Pseudomonas fluorescens* formulation @ 5 ml / lit of water after 45 days after transplanting and at every 10 days intervals.
e. Use of tolerant varieties.

Brown spot *(Helninthosporiun oryzae)*

Symptoms

a. The disease occurs in both nursery and main field.
b. Symptoms appear on the seedlings as minute, small, circular, brown lesions which may girdle the coleoptile and cause distortion of the primary and secondary leaves.
c. On the leaves of older plants, the fungus produces circular to oval lesion that have a light brown to grey center surrounded by a reddish brown margin.
d. Under severe infection the spots coalesce affecting the entire leaf.
e. The spots also appear on glumes and grains causing black discoloration on the grains.

Management

a. Provision of field drainage.
b. Sanitation and crop rotation.
c. Spray Bordeaux mixture 0.1% at regular intervals reduces the disease.
d. Spray with *Pseudomonas flourescens* @ 5ml / lit water.
e. Periodical spray with Jeevamrit.

Sheath Blight *(Rhizoctonia solani)*

Symptoms

a. Early symptoms include oval sheath spots (lesions) at or just above the water line, often at the junction of the leaf and sheath.
b. Early lesions are pale green to off-white with a narrow purple-brown or brown border, usually 2″ or less wide and 1-2″ long on most varieties.
c. Lesions may join as the disease moves up the plant. Both sheaths and leaves are commonly attacked and killed as the disease grows upward.

Management & Control

a. Burning of previous crop residue.
b. Crop rotation with oil seeds and pulses.
c. Foliar spray of *P. fluorescens* @ 2.5 kg/ha mixed with 50 kg FYM after 30 days of transplanting.
d. Spray with Jeevamrit fortnightly.
e. Spray fresh cow-dung extract for bacterial blight by dissolving 20 gms dung in one litre of water; allow to settle and sieve. Cow's urine + water at a ratio of 1:8-10 properly filtered can also be sprayed.
f. Apply bleaching powder @ 5 kg/ha in the irrigation water for preventing the spread of bacterial leaf blight.
g. Good cultural practices.

9. Maize (*Zea mays)* [Code No. – 43]

Maize is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is grown as a rainfed crop in upland and jhum land both as mono or mixed crop. It has very high yield potential and is a promising crop for the purpose of human consumption as well as animal feed. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. The yield of maize can be increased through adoption of high yielding varieties and improved technology.

1. **VARIETIES RECOMMENDED**

A. For Higher and Mid-altitudes (800 m above MSL)

Local Varieties:

- Local white Kernel
- Local Yellow Kernel

High Yielding Varieties (HYVs):

- HQPM-1 (High quality Protein Maize).
- RCM-75 (Research Complex Meghalaya).
- RCM-76, RCM-1-2, DA61A.

B. HYV for Lower Altitudes (Below 800m)

- HQPM varieties

C. HYBRID VARIETIES

- Hybrid All-rounder, HQPM varieties.

2. **CLIMATE AND SOIL**

Maize requires humid climate from the time of sowing to the end of its reproductive phase. Extremely high temperature and low humidity during flowering period results in poor grain formation. Optimum rainfall requirement of 50 cm to 75 cm results in proper growth and development. This crop usually grows well under temperatures varying from 21°C to 27°C, although it can tolerate temperatures as high as 35°C. Frost is injurious to this crop. Maize can be grown on a wide range of soil but thrives well in well drained loamy and sandy loam soil. Low laying area where water stagnation during rainy season occurs must be avoided.

3. **SOWING TIME**

- For **higher altitudes:** mid- March to mid-April
- For **lower regions:** April to May
- **Rabi (winter) crop:** October to November in lower altitudes(Irrigated)

4. **SEED RATE & SEED TREATMENT**
   - **Seed Rate:** 15 -20 kg / ha
   - **Seed Treatment:** Seed Treatment with Jeevamrit and *Trichoderma* @ 5 gms / Kg Maize seeds is advocated before sowing.
5. **LAND PREPARATION**

Maize requires a firm and compact bed free from stubbles and weed. One deep ploughing should be given followed by two or three harrowing to bring the soil to a fine tilth.

6. **MANURES**

Apply 12.5 tonnes / ha of FYM or compost along with 2 kgs of *Azospirillum* and incorporate in the soil. Panchagavya may be applied 15 days before planting.

7. **SOWING**

Furrows are made at a distance of 70 cms apart and manures should be applied in the furrows. Seeds are then sown in line at a distance of 20 cms (8 inches) and depth of 7.5 -10 cms then covered over with soil.

8. **IRRIGATION**

The Kharif crop requires irrigation only when there is an extended period of water stress. However, the Rabi crop needs frequent irrigation at intervals of 15-20 days.

9. **INTERCULTURE**

Weeding is necessary as weeds interfere with the plant growth particularly during the initial stages. Weeding should be done as required. Earthing up should be done after every weeding for a better crop stand. Intercultural operations should not be continued after flowering.

10. **PLANT PROTECTION**
    a. **DISEASES:**

    Leaf Blight: Manifestation of oval to round, yellowish-purple spots on leaves. The affected leaves dry up and appear as if burnt. In severe cases, the plants may become stunted, resulting in poorly-formed ears. The crop can be sprayed with *Trichoderma* @ 5 gms / litre water + *Pseudomonas fluorescence* @ 5 ml / litre water.

    b. **INSECT PESTS:**
        i. **Stem borer:** These borers feed on leaves in the earlier stages. Later on they bore into the stem and cobs, rendering the plant unproductive. After harvest, the stalks and stubbles should be collected from the field and burnt.
        ii. **Red Hairy Caterpillars:** Caterpillars feed and destroy the whole plant if the attack is in the early stages of growth.

        Control:

        - Egg masses and young caterpillars should be collected as soon as detected and destroyed.
        - The field should be ploughed out after the crop is harvested so as to expose pupae.

iii. **Aphids:** Tiny, soft bodied insects, usually green in colour. Nymphs and adults suck the sap from leaves and young shoots. The crop can be sprayed with *Beauveria bassiana* @ 5gms / litre of water.

iv. **Termites:** These pests attack young seedlings as well as mature plants; attack is also visible on roots and lower parts of the plants.

Control: Soil treatment with Soldier @ 2 kg per hectare and mixed well with the soil. Soil drenching should be done with *Metarhizium* @ 5gms / litre water.

11. **HARVESTING**

Cobs which are to be utilized as grain should be harvested when the grains are almost dry or containing roughly 20% moisture. The appearance in the grains of composite and high yielding varieties however may be misleading as grains become dry while the stalk and leaves are still green. The cobs are removed from the standing crop and sun dried before shelling. If kept for seed purpose or meant to utilize at a later stage the cobs are to be retained in their jackets.

10. Baby Corn [Code No. – 43]

Baby corn refers to the young flowering corn ear harvested between two days before and three days after silking, depending upon the development of the plant and size of the ear shoot (baby corn). It is a new product in the market as a high value crop, which can boost the economy of the poor hill farmers by diversification in their farming system. It is a delicious, decorative and nutritious vegetable. It should be used as salad or as ingredient in various preparations viz., Chop - its Suey (Chinese dish), soup, deep-fried with meat or rice, souted with other vegetables, pickles and corn pakoras. Its nutritive value is comparable with several high priced vegetables like cauliflower, cabbage, French bean, spinach, lady finger, brinjal, tomato, radish, etc. It is rich in phosphorous (86 mg/l00g) in comparison to 21 to 57 mg phosphorous content in other common vegetables. It is an attractive low calorie vegetable, high in fiber and without cholesterol.

Marketing and Processing: Baby corn can be marketed as fresh husked/de husked young cobs, canned products and pickles. Baby corn can be canned in a solution of brine (3%), sugar (2%) and citric acid (0.3%).

Varieties: A few varieties suitable for baby corn production are as follows: VL-45, RCM 1-1, RCM 1-3, MLY, MTH-14

Time of Sowing: April to end of May and August to September

Soils: Deep, medium and loamy types are preferred. It does not come up well in alkaline and waterlogged soils. The optimum pH range is 6.5 to 7.5.

Spacing:

Row to row spacing - 45 cm (18")
Plant to plant - 15 cm (6")

Seed rate: Baby corn seeds are small and light and hence seed rate is low i.e. 20 kg/ha

Weeding: Field is kept free from weeds especially during the first month. Spraying of Butachlor @ 2.5 kg dissolved in 750 litres water on the day of sowing or the day after rain keeps the field free from weeds in early stage of growth.

Manures and Fertilizers: Manures and fertilizers both play important role in the Baby corn cultivation. Baby corn seed should be inoculated with N fixing microorganisms like *Azospirillum*, *Azotobacter*, etc. and phosphorus solubilizing bacteria (PSB) at 20 g/kg seed. Well decomposed FYM at 15 t/ha should be applied 20 days before sowing of crop with 150 kg rock phosphate. Crop residue of baby corn plant after harvesting should be incorporated in the field. FYM doses can be reduced up to 10 t/ha if vermicompost is applied @ 2-3 t/ha along with rock phosphate @150 kg/ha. Neem cake can also be added @150 kg/ha to the field for effective control of soil borne insect pests. Baby corn plant should be intercropped with legume crops or legumes should be incorporated in the cropping systems. Green manuring (dhaincha) and green leaf manuring (Tephrosia) are also very good source of plant nutrients to be incorporated into the soil.

Detasseling: Detasseling is an essential operation in the cultivation of baby corn. Remove the tassel of the plant as soon as it emerges from the flag leaf and before it starts shedding pollen grains. This operation prevents fertilization. The de-tasselling can be generally done after 45 days of planting, depending on the variety and continues for 8 to 10 days.

Harvesting: Depending on the place and time of cultivation, 50-55 days after sowing, 3-4 small shoots (ears of 10 to 15 cms long) are seen in each baby corn plant. Couple of days later, the silk emerges and the Shoots are ready for harvest. Within 24 to 48 hours of reaching this stage (silk emergence), the shoots should be harvested. At this stage, the shoots with husk are about 15-20 cms. If harvest is delayed, baby corn becomes tough and unpalatable. Second picking is also possible. About 1,50,000 to 200,000 shoots per hectare can be harvested if optimum plant population is maintained. Net income is ` 40,000/- to ` 50,000/- per ha from one crop. 2-4 crops can be raised annually depending on the agro climatic conditions.

Yield: Per hectare yield of ears with and without husks works out to 7 to 7.5 tones and 1.5 to 2 tones, respectively, from a single crop of maize. Shoots lose freshness once the husks are removed. Hence, these should be stored properly. Otherwise, the dehusked shoots should be either canned or used for table purpose without much delay. In addition to the baby corn, 10- 12 tones of green fodder is also obtained.

11. Cole Crops (*Cruciferae members*) [Code No. – 22]

Cole crop group includes cabbage, cauliflower, broccoli, kohlrabi, brussels sprouts and chinese cabbage. Cole crops are commercially cultivated in almost all the district in Meghalaya. They are known for their vitamins –rich, high fibre, low fat and low calorie properties. They are rich in Vitamins C, beta carotene, fibre, antioxidants and phytochemicals which help in preventing cancer and heart diseases. The mostly cultivated cole crops in Meghalaya are Cabbage, Cauliflower and Broccoli.

Climate – Cole crops are cool season vegetable preferring less than 20°C temperature for optimal growth and development.

Soil Deep-well-drained loamy – sandy loam soil with adequate organic matter. Soil pH between 6 to 7 is the best. If the soil pH is below 5.5 slaked lime should be applied (as per soil test) at least a month before transplanting.

Sowing Time & Varieties:

Cabbage

June - July	CH- 21, CH – 200, Green Empress, Pusa Ageti, Mahyco -139, Wonderball, US – 2154
August - September	Bahar, BC -76, BC -79, Pride of India
October - November	Raj - 2 (Large), Raj – 2, Green Challenger

Cauliflower

June - July	Himkaran (Hybrid), Pusa early synthetic, Local Variety
August - September	Pusa sharad, No. 497 (Hybrid)
October - November	Himari (Hybrid), Mahina (Hybrid), Poosi, Meghalaya local

Brocolli -

June - July	Padhana, Shweta

Nursery Management – A nursery area of 60 sqm is required to raise seedlings for transplanting in one ha area. Raised bed of 15 cm height and 5x1 m size should be prepared. Well decomposed organic manure should be mixed with the soil. The seeds should be sown in furrows 15 cm apart and 1.5 cm deep and covered with fine media. Then drench the seed with *Trichoderma* & *Pseudomonas* @ 5 gm/1 lit water to prevent diseases. Against soil insects metarrhizium can be incorporated and mix with the soil or *Beauveria bassiana* @ 5 gm/lit of water may be drenched. The bed should then be covered with thin layer of dry grass to prevent evaporation and maintain temperature. As soon as seed germinate remove the grasses and follow operations as per requirement. The seedlings can be grown in protected shelters like polyhouses, tunnels or provide with shades. Another method of nursery raising is using pro-trays. Pre-mixed media of soil and manure are filled in the tray. Seed is then place in each hole. Covered the seed with fine media and drench with Bio-pesticides as discussed above. The trays can be place on raise platform provided overtop with shade.

Field Preparation – The field should be properly prepared and planting should be done either on raised beds or ridges to prevent water logging. Land should be prepared to fine tilth. It is advisable

to apply slaked lime about 30 days before planting after doing soil test and getting the recommendation.

Nutrient Management – The nutrient requirement of cole crops are moderately high. Well decomposed FYM or compost should be applied @ 15-20 T/ha (1.5-2 kgs/sqm) along with Neem cake @ 200 gm/sqm at the time of final land preparation. Roots of seedlings should be dipped in *Azotobacter* or *Azospirillum* & PSB (40 gms in 500 ml water) for 20-30 mins before planting. In addition vermi-compost @ 1kg/sqm further improved production of cole crops. Bone meal and wood ash can also be applied as source of P and K.

A dilution of Jeevamrit can also be sprayed one month after transplanting and then after every 21 days (3to 4 sprays is required) for a good crop.

Transplanting – After 4-6 weeks the plants are ready for transplanting, avoid planting of over matured seedlings. To harden the roots stop watering one day before transplanting but water 1 hour before transplanting.

Spacing - Spacing depends on varieties but generally 60 cm (row to row) and 50 cm (plant to plant) is optimum for cole crops.

Spacing of Cabbage and Cauliflower is dependent on cultivars. The early cultivars 30 cm x 30 cm but late cultivars 45 cm x 30 cm (plant to plant and row to row). The optimum spacing for broccoli is 45 cm x 45 cm. In very rich soils, spacing can be reduced to 45 cm x 30 cm to avoid stem hollowness due to rapid plant growth. At wider spacing plants produce more laterals and closer spacing delays maturity.

Interculture and irrigation – Cole crops are shallow rooted restricted within 15-20 cm of soil. Hence, light earthing up should be done 30-45 days after planting. Regular shallow hoeing at early stage is advisable to remove weeds and provide soil mulch. Maintain sufficient moisture level.

Harvesting and storage

The cabbage heads should be harvested when they attain full size and are preferably early morning or afternoon. For cauliflower when the curd have attained proper size and are compact. Delay in harvesting will result in loose and poor quality curd. While harvesting, the inner 2-4 leaves should be retained along with the curd to provide them adequate protection against injuries during handling, packing and transport. Broccoli, the crop should be harvested at the correct time i.e., before the buds open and when the bud clusters are compact. The heads are cut-off with about 15 cm of the stem attached. After harvesting its head should be immediately sorted, graded, packed in baskets and sent to market.

According to demand of the market, we have to sort the flowers in three grades big, medium and smaller size. Then with precaution pack in basket or crates for sending to market.

Insects

Red ants – Feeds on the roots of seedlings, plant wilt and ultimately die.

Cut worms – The caterpillars cut young plants at ground level and feed on tender leaves and shoots.

Cabbage butterfly – Caterpillar on emergence fed on foliage, often defoliating the plants completely.

Semi loopers – green caterpillars feed gregariously on leaves.

Aphids – Light green nymphs and adults suck the sap from leaves and tender parts including inflorescences excretes honey dew which attracts ants and favours the growth of sooty mould.

General Management against insects

1. Deep and early ploughing of the field.
2. Application of well decomposed organic manure.
3. Clean cultivation and frequent monitoring of the field.
4. Handpick or remove the infested parts, eggs, larvae, caterpillars etc. and destroy them.
5. Place bamboo perches for predatory birds.

Ants & Cutworms:-

1. Follow steps 1 – 5 above.
2. Flooding the field with water.
3. Plant two rows of Mustard for every 25 rows of cole crops.
4. Spray Neembase insecticide @ 6-7 tsp / 16 lits water.
5. Soil application @ 2 kgs / hec or drench @ 2.5 ml / lit with soldier (EPN).
6. Soil application with Metarrhizium @ 5 gm / lit of water.
7. Drench with *Beauveria bassiana* @ 5 gm / lit water.
8. Apply mixture of water, cow's urine and neem oil (80+20++50 ml) @ 100 ml / plant at weekly interval starting from 15 DAT to manage soil pest.

Cabbage butterfly

1. Follow steps 1 – 5 above.
2. Grow marigold on the buds or border of the field as trap crop.
3. Installation of Trichocards (*Trichogramma* brasicae) one week after transplant.
4. Spraying with *Beauveria bassiana* or Bt @ 5 gm / lit of water.
5. Spraying with Neem based insecticide @ 6-7 tsp / 16 lits water.
6. Spraying with diluted decoction of Tobacco, Chilli etc will prevent insects.

Semi looper

1. Follow steps 1 – 5 above.
2. Grow cole crops and mustard (25:2 rows) as trap crop.
3. Spray with Neem based insecticides @ 6-7 tsp / 16 lits.

Aphids

1. Follow steps 1 – 5 above.
2. Grow cole crops and mustard (25:2 rows) as trap crop.
3. Installation of yellow sticky trap and light trap above crop canopy @ 15nos. / hec.
4. Spray with Bi-insecticide.
5. Spray with Neem base insecticide.

DISEASES

Damping of – Stem of seedlings softened at the ground level, plant collapse and die.

Management –

a) Sow seeds thinly on raised beds or trays.

b) Drench the soil with *Trichoderma viridae* @ 5gms / 1 lit of water and also spray on young seedlings.

Black rot – Blighting of the leaves from the margin to mid rib in V-shape, blackening of the vascular bundles which is a characteristics of the disease.

Management –

a) Hot water treatment of seeds at 50 ° C for 30 mins.
b) Crop rotation with French bean and green peas.
c) Remove affected parts and burn.
d) Proper drainage and free air movement to dry the moisture present on the plants.
e) Apply, drench and spray with *Trichoderma viride* @ 5gms / 1 lit water.

***Alternaria* leaf spot –** Black spots appear on the leaves, later the spots will form concentric zonations.

Management –

a) Crop rotation.

b) Hot water treatment of seeds

c) Apply drench and spray with *Trichoderrma viride* @ 5gms / 1 lit water.

Club root – Roots enlarge to form "Clubs". Affected plants become stunted.

Management –

a) Application of slaked lime to reduce soil acidity for if pH falls below 6.5 it favours the disease

b) Field Sanitation and removal of infected plants

c) Crop rotation with non-host crops like pulses for minimum of four years.

d) Avoid excess irrigation and prevent water flow from infected field as the spores easily transported through water or wind.

e) Seed treatment with *Trichoderma viride* @ 4 gm / kg seeds and *Pseudomonas florescence* @10 gms / kg of seeds, followed by seedling dip @ 5gm / lit and soil application @ 2.5 kg / ha along with 50 kg FYM before planting.

12. Tomato (*Lycopersicon esculentum*) [Code No. – 75]

Tomato is one of the solanaceous vegetable grown in the temperate as well as sub-tropical zones of the State. It has a high nutrients value being a good source of vitamins and minerals also rich in medical value. It supplies vitamin C. The pulp and juice are digestible and blood purifier. It is reported to have antiseptic properties against intestinal infections. Lycopene's, bioflavonoid closely related to beta carotene are potent antioxidants present in Tomato and are known to have natural cancer-fighting properties. Cooking of tomatoes increases the effectiveness of the lycopene. It is also very good for the stomach and intestine. The fruits are eaten raw or cooked. Tomato is also processed to ketch-up, puree, paste, powder and margarine.

1. **Climate and Soil:-** A warm season vegetable crop. Grown extensively in cool season. Optimum temperature require for its cultivation is 15 – 27 ^{o}C. Under extreme high and low temperature condition, the yield and quality of the fruit is reduced. Excessive rains adversely affect flower drop and fruit setting. Cloudy and foggy condition increases the incidence of diseases especially in the upland temperate zones.
2. **Soil** – It is grown in varied types of soil from sandy loam to clay having proper drainage. Sandy loam rich in organic matter is ideal for cultivation. Optimum PH is 6-7 but can also tolerate moderate acidic and saline soil. In acidic soils, liming is beneficial. Meghalaya soils are acidic in nature, therefore addition of slaked lime is recommended for better crop.
3. **Varieties –**

   Hybrid – Avinash – 2, Rocky, 017, Suraksha, Vaishali, Arka Meghali, Arka Vishal.

   Wilt resistance Varieties – Arka Alok, Arka Abha, Megha Tomato–1, Megha Tomato–3, Suraksha.
4. **Seed rate** – Hybrid variety = 400 gms / ha. Open pollinated Variety = 500gms / ha
5. **Sowing time** – High altitude – 1) February - June.

   Mid and Low altitude – 1) February `- June.

   2) September – December.
6. **Nursery** –

   1st Method - 250 sq.m area is required to grow seedlings for 1 ha of land. Raise beds of 1 m breath and convenient length are prepared. FYM @ 5 kgs / sq.m is used. The beds should be drenched with *Trichoderma* + *Pseudomonas* culture @ 5gms / lit water before planting to protect the seedlings from damping off. To prevent damage by soil insects, *Metarrhizium* or *Beauveria bassiana* @ 5gm / lit of water can be applied or drenched in the soil. Seeds are sown with row spacing of 10 cm and seed spacing of 0.5 cm. The beds are covered with a layer of equal properties of FYM, soil and sand mixed in equal properties.

   2nd Method – Raising nursery in pro-trays.

   a. The pro-trays should be properly clean.
   b. Mix equal parts of farm yard manure, soil and sand.
   c. Fill the mixture in the pro-trays.
   d. The seed are place one in each hole then thinly cover with soil.
   e. Drench with *Trichoderma* & *Pseudomonas* culture @ 5gm / lit water.
   f. Keep the trays in poly-house or shade house. They can also be kept outside on platforms and provide a shade over them to prevent damage by adverse climatic condition. Then cover the trays with wet gunny bags till they sprout.

Advantages of pro-trays Nursery

1. The exact quantity of seedlings can be known.
2. It prevents unnecessary spoilage of seedlings due to congestion, pest and adverse climate.
3. The seedlings get ample space to anchor/strengthen their root system and get sufficient nutrient plant-wise.
4. The seedlings can be transplanted any time of the day without any after planting stress.

7. **Seed Treatment –** Untreated seeds are treated with *Trichoderma veridae* @ 5gms/ lit. soak the seeds for 24 hours, drain and dry in shade for half an hour before sowing in Nursery beds or pro-trays.
8. **Field preparation –** Liming should be done one month before planting as per soil test and recommendation. The field should be brought to fine tilth and make raise beds to prevent water logging.
9. **Organic Nutrient management –** Tomatoes are considered heavy feeders because of their rapid growth and long production system. Farm yard Manure or Vermi Compost @ 25-30 mt/ha (4-8 kgs/sqmt) to be applied. Bio-fertilizers loke Azotobacter, *Azospirillum*, PSB and others not only play an important role in maintaining good health of the plants but also serve as a natural source of plants nutrient to increase productivity. These can be mix @ 1 kg + 100 kgs FYM or compost, kept moist and covered for few days while turning it periodically for proper multiplication and spread of micro-organism before using it. Rock phosphate or Bone meal for phosphorous and potassium sulphate or wood ash for potassium source will give good crop response.

   Boron and zinc are important micro nutrients for Tomato. Boron is applied in the form of borax @ 20-25 kgs/ha as soil application. Spraying 0.2-0.4 % borax at fruit formation stage help in proper fruit development. In zinc deficiency, Bio zinc as water soluble organic granules should be mixed with well decomposed FYM and applied @ 5 kgs/ha in the soil.

10. **Transplanting Time -** 4-5 weeks after sowing.
11. **Transplanting –** Healthy, disease free 25-30 days old seedlings are transplanted in the main field at the spacing of 90x60 cm (Hybrid) and 60x60 cm (other varieties). Seedling treatment with *Trichoderma* and *Pseudomonas* culture @ 5 gms/1 lt. water for 15-20 mins before planting is recommended. To prevent soil insects, drench the soil with *Beauveria bassiana* or Metarrhizium @ 5gm/1 lit water.

Bare rooted seedlings should be preferably transplanted in the evening whereas pro-trays seedlings can be transplanted any time of the day.

Hardening of seedlings before transplanting is essential. It is done by withholding water 4-5 days before uprooting the seedlings.

12. **Staking and Pruning -** Tomato plants should usually be held off the ground with individual stakes or by a trellies strung along a row stakes. Another way of staking is by overtop trellies and strung vertically with nylon twine or strong thread.

Tomato plants should be prune to remove all the leaves and suckers growing from the base of the plants up to certain inches upward to enable free entry of air and sunlight thereby reduces disease incidence.

13. **Top dressing** – Top dressing can be done at 7-10 days interval with anyone of the following manures :-
    a. Fresh cowdung slurry @ 1 kg/10 lit water (50kgs/ha)
    b. Biogas slurry @ 1kg/10 lit (50kgs/ha)
    c. Cow's urine (8-10 times dilution) – 500 lits/ha.

d. Vermi wash (8-10 times dilution) – 500 lits / ha.
e. Foliar spray can also be done after proper dilution and straining.

14. Interculture and water management :-

Light hoeing is required to remove weeds and loosen the soil for better aeration and root growth. Tomato is shallow – rooted crop and roots are restricted within 15-20 cm of soil so light earthing up should be done after 30 days of transplanting. Adequate water levels need to be maintained throughout cropping season. Heavy irrigation is avoided as it causes soil-borne diseases like wilt and collar not. Slight water stress during fruit development at 60-80% of the estimated requirement is sometimes recommended for maximum flavour.

15. Harvesting - Tomato is harvested at several stages i.e. mature green, turning pink, red ripe and overripe. The stage of harvesting depends upon the purpose for which they are harvested. Generally, tomatoes for distant market are harvested at mature green stage. (When the blossom end turns slightly pink). This will ensure supply of nutrients to other underdeveloped fruits, prevent susceptibility to pests and fruits are more durable during handling and transportation. To prevent unwanted bruises and marks on the fruits they should not be clean immediately after harvest but when they have developed good colour and ripened under favourable condition.

Yield - Hybrid = 500 Qt / ha

Open pollinated = 250 qts / ha

Physiological disorders

Blossom end rot: - Calcium moves only in water- conducting tissues of the plant. When water movement into the plant is restricted, a localize Ca deficiency often develops by blackish sunken rot at the blossom end. Secondary infestation usually follows. The cause of this disorder is considered to be calcium deficiency in the developing fruit. Extreme fluctuation in moisture results in blossom end rot. Hence, consistency is required in irrigation. Application of slaked lime @ 20 gm / sq m a month before planting and foliar spray of calcium chloride (3g / lit of water) also help in controlling this disorder.

Insects:-

1. **White fly** - Whiteflies damage plants in two ways: directly and indirectly. Direct damage results from their feeding activity, which involves them sucking plant sap. Both the adults and nymphs contribute to direct damage. In addition, as they feed they excrete honeydew (a sugary substance), on which the sooty mould fungi feed. The resulting dark splotches on the leaves may reduce photosynthesis and other physiological function of plant.

Management:-

a) As flies are attracted to yellow background, place above crop canopy yellow plates / plastics / tins with oil / grease so that the attracted flies get stuck to the surface.
b. Use petroleum – oil based spray (eg Neem oil or Neembicidine @ 10 ml / lit at 20 days interval.
c. Spray with *Beauveria bassiana* (Helicon – L or Bio power) @ 16 tsp / 16 lts water
d. Garlic (5% extract also effectively control white flies and aphids).

2. Fruit borer (*Spodeptera litura* and *Helicoverpa armigera*)

The young larvae feed on tender foliage while advanced stages attack the fruits. Larva bore circular holes, feed and may destroy the fruits.

Management:-

1. Integrated package has to be adopted for effective control of this pest.
2. Regular monitoring, collection and destruction of fruit borer larvae.
3. Transplant two rows of marigold for every 16 rows of tomato as trap crop, (the female will be attracted to marigold flowers and lay eggs) and it should be sprayed with NPV. Marigold should be 15 days older than tomato plants so that they flower at the same time.
4. Mix cropping with other vegetables eg. Mustard, Cabbage, Cauliflower.
5. Installation of *Trichogramma brasiliensis*.
6. Pheromone trap can be used for mass trapping of adult fruit borer.
7. Spraying with *Beauveria bassiana* (Biopower-L, etc) @ 16 tsp / 16 lits water.

3. **Aphids –** Adults and nymphs suck sap from the plant. They reproduce rapidly therefore their population can become very large before they are noticed. The infestation cause discoloration or mottling of foliage, excrete honeydew on which sooty mould grow.

Management

1. Regular monitoring, collection and destruction of infested leaves and shoots
2. Used petroleum –oil based spray (Neembicidine or Neem oil) @ 10 ml / lit at 20 days interval.
3. Garlic (5 %) extract spray.
4. Installation of yellow sticky trap.
5. Spray with *Beauveria bassiana* @ 16 tsp / 16 lits water

4. White grubs and Cut –worms:-

They are the most destructive soil insects which cut the tender plants and feed on them.

1. Spray with multineem @ 5 ml / lit water.
2. Spray with *Bacillus thuringiensis* (Bt) or Dipel @ 12-13 tsp / 15 lits water.
3. Spray with *Beauveria bassiana* (Bio-power, Helicon – L) @ 16 tsp / 16 lits water
4. Soil application with *Metarrhizium* @ 5g / l of water.
5. Installation of light trap and pheromone trap @ 15 nos. / ha.
6. Drench the soil with EPN- Soldier @ 2.5 ml / l of water.

Diseases

1) Late Blight (*Phytophthora infestant*)

a. Removal of infected plant debris after harvest.
b. Crop rotation with non-solanaceous crop.
c. Provision of drainage.
d. Maintenance of optimum spacing and lower leaves clearance allow free air circulation.
e. Spray with *Trichoderma vedidae* (Viricon L, etc) and *Pseudomonas florescence* @ 16 tsp / 16 lits water.
f. Spray with MATW – 2 (Mix 5 gms Turmeric powder and 1.5 gms tsp Asofoetida powder in 10 lits water).

2) Wilt (*Fusarium oxysporum*)

Management

a. Field sanitation
b. Crop rotation with non-solanaceous crops
c. Spray with a mixture of 5 gms Turmeric power and 1.5 gm Asofoetida power in 10 lits water. And also drench the soil three times i.e. at 15, 30 and 45 days after transplanting.
d. Spray with *Trichoderma vedidae* (Viricon L, etc) and *Pseudomonas* florescence @ 16 tsp / 16 lits water.

3) Bacterial leaf spot *(Xanthomonas Campestris)*

Management

a. Field sanitation
b. Crop rotation with non-host crops like rice, maize, etc.
c. Avoid working in the field when field is wet.
d. Spray of copper fungicides like Bordeaux mixture.
e. Irrigation should be done early in the morning so that the plants will get dried during night.

Nematode

Management

a. Apply neem cake @ 250 kg/ha at 20 DAP to reduce nematode.
b. Planting of marigold also reduces nematodes.

Viral diseases – Tomato mosaic virus and leaf curl virus.

Management

a. Use of disease free seeds for sowing.
b. Sanitation.
c. Removal and distinction of infested plants.

Harvesting

Tomato is harvested in different pickings. The interval between pickings depends upon the weather. Tomatoes are normally picked at four days intervals during warm season and at weekly intervals when weather is cool. Tomatoes should not be pulled from vines but should be picked with a twisting motion of hand to separate fruits from stem. Tomatoes are harvested at several stages i.e., mature green, turning pink, red ripe and over ripe. The stage of harvesting depends upon the purpose for which the tomatoes are harvested. Generally, tomatoes are harvested at mature green stage for distant marketing, pink to light red stage for fresh consumption and red ripe stage for seed production. Fruits harvested at immature green stage are usually tough leathery and developed poor colour when ripened artificially. Fruits picked in mature green stage developed good colour when ripened under favourable conditions. Tomatoes grown for processing are harvested when fully ripe to ensure desired quality and red colour of the product. Quality characteristics such as flavour, texture and colour in fruits is superior to those harvested at earlier stage of maturity.

Yield and Storage

The yield depended upon various agro-climate factors, including soil fertility, and cultivar and cultural practices. The average yield of tomato under protected conditions may vary 6-8 kg/sq m if proper care is taken. The average yield per plant may be 3-4 kg/plant with the fruit number of 40-60/ plant and fruit weight of 80-90 g. Tomato yields around 10-15 t/ha in open field whereas in polyhouse it yields around 25-30 tonnes/hectare under good management practices. The best storage temperature is from 12° to 15° C. When stored at freezing point, the fruits show low temperature injury. Mature green fruits can be kept for as long as 30 days at 10° to 15°C. Ripe tomatoes can be kept for 10 days at 4° C. The recommended relative humidity is 85-90%.

13. Pea (*Pisum sativum*) [Code No. – 59]

There are two types of peas. Garden Pea and Field Pea. Garden pea is for table purpose, while field pea is grown as forage crop, mulching crop and green manuring crop. Pea is highly nutritious as it contains digestive protein, carbohydrate, minerals and vitamins. Peas are also rich in calcium, amino acids, sugar and phosphorous. Pea is a winter crop, high temperature is injurious to pea as it causes poor fruit set and favour the incidence of diseases.

Soil type – Pea grows in well-drained, sandy loam soil. Pea is highly sensitive to water logging condition. Preferable soil pH should be 6-7.5 range.

Varieties – Varieties that are most suitable with our region are DMR – 7, DMR – 50, TRC – P8, TRCP9, Rachna, Ambika, Arkel, Bonevile.

Seed rate & spacing

Dwarf varieties	75 - 100 kg / ha, at 30 x 4 cm apart
Tall varieties	75 – 100 kg / ha at 30 x 4 cm apart by planting in rows.

Sowing time – August to September.

Organic Nutrient Management – Peas being a leguminous crop does not require too much nutrients. We need to apply FYM or any compost @ 15 t/ha. Besides application of manures, it is essential that seeds should be treated with rhizobium inoculum for better nodulation and high yield. About 200 g of rhizobium in 200 ml of water is mixed together with 10 kg of pea seeds, which is to be slightly dried in shade and then they are ready for sowing.

Staking of pea plant – Staking should be done while the pea plant is still at a young stage.

Weeding – Field should be free from weeds for a period of 40 – 50 days after sowing. Heavy weed infestation reduces the yield of the pod to a large extent. Therefore two weeding and hoeing are needed after 3-6 weeks of germination.

Pest in Peas

1. **Leaf miner –** Maggots make zig-zag mines in the leaves, eat green matter and pupate inside the leaves. The infested leaves become whitish and dry ups.

   Management & Control

   a. The infested leaves should be destroyed to prevent multiplication of the damage.
   b. Spraying of Neem oil @ 3ml/ 1 lit water and second spray at 20 days interval.

2. **Aphid –** Light green nymphs and adult suck the sap from leaves & tender parts including inflorescence excrete honey dew which attracts ants and favours the growth of moulds.

   Control

   a. Spraying of *Beauveria bassiana* @ 5 g /1 lit of water 2 times at an interval of 20 days.
   b. Spraying of Neem oil/ Neembicidine @ 6 tsp /16 lits of water 2 times at an interval of 20 days.

3. **Semilooper and pod borer –** These make way into the pods and feed on the seed within. To control we should

Control

a. Spraying of neem oil @ 3 ml / lit water.

b. Spraying of Biolep @ 12-13 tsp in 16 lits of water.

Disease

1. **Powdery Mildew –** white powdery spots appear and spread throughout the leaves, stems and pods of the pea plant. This condition ultimately reduces the productivity.

Control

a. Application of 2.5 kg sulfex per hectare.

b. Spraying of 1 tsps of baking soda mix with 3 lits of water.

2. **Wilt –** This disease is seen in seedling stage. The root rots and plant become yellowish at the lowest leaves followed by wilting.

Management & Control

a. Pea should not be sown early or before the sowing time.

b. Select wilt – resistant varieties

c. Crop rotation for at least 2 – 3 years with suitable non- leguminous crops should be followed.

d. After harvesting the affected plants should be burnt.

e. Spraying & drenching with *Trichoderma* @ 5g / 1 lit of water.

3. **Rust –** Earlier symptoms are yellow spots and the stem of the plant becomes malformed and the plant dies.

Management & Control

a. After harvesting the affected plants should be burnt.

b. Crop rotation for at least 2 – 3 years with suitable non- leguminous crops should be followed.

c. Spraying & drenching with *Trichoderma* @ 5 g / 1 lit of water.

14. French Bean *(Phaseolus vulgaris)* [Code No. – 27]

French Bean is a nutritious crop containing protein, carbohydrate, fat, calcium, phosphorous, iron and vitamins. There are two types of French bean, Dwarf and Tall.

Soil – French bean prefer well drained soil having pH of 6.5 - 7.5. Except saline soil it can be grown in all types of soil.

Field preparation – The land should be properly ploughed and 15 tonnes/ha of FYM should be applied at the time of land preparation.

Varieties – Dwarf variety - Selection - 9

Tall variety - Manipur

Seed rate – 50 - 75 kg per hectare

Spacing – 30 x 10 cm

Sowing time – March – July

Sowing – Before sowing the seeds should be mixed with 200 g Rhizobium in 200 ml water for 10 kg seeds which is to be slightly dried in shade and then they are ready for sowing.

Intercropping - Usually French bean is sown as inter crop with Maize and Soya bean.

Staking – Short variety French Bean do not need staking while tall variety need staking to give support to the crop with the help of bamboo sticks.

Pest in French bean

1. **Pod borer** – The green caterpillars make holes in the pods and feed on the seeds.

   Control

   a. Spraying Biolep @ 12-13 tps in 16 lit water
   b. Spraying of Neem oil @ 3 ml in 1 lit water.

2. **Aphids** – Small insects suck the sap from the leaves, tender shoots and flower buds curl, deform and dry up.

   Control

   a. Spraying of *Beauveria bassiana* @ 5 g/1 lit of water.
   b. Spraying of Neem oil/ Neembicidine @ 6 tsp /16 lits of water 2 times at an interval of 20 days.

3. **Leaf eating caterpillar** – These caterpillars feed on the leaves and tender plant parts.

   Control

   a. Spraying Biolep @ 12-13 tps in 16 lit water
   b. Spraying Neem oil @ 3 ml in 1 lit of water.

Diseases in French Bean

1. **Anthracnose** – Black spots with reddish or yellowish margin on all portion of the plant. There is lesion on hypocotyl and causes death to the plant. Seeds inside the pods are also infected.

   Control

   a. Spraying of *Trichoderma*, Biofor Pf, Biozene or Bio-cure B @ 5 g /1 litre of water.

2. **Rust** – There are numerous powdery patches on the leaves and other green parts of the plant.

   Management & Control

   a. After harvesting the affected plants should be burnt.
   b. Crop rotation for at least 2 – 3 years with suitable non - leguminous crops should be followed.
   c. Spraying & drenching with *Trichoderma* @ 5 g /1 lit of water.

3. **Leaf spots** – These are small circular or irregular spots found on the leaves of French bean plant.

   Control

   a. Spraying of *Trichoderma*, Biofor Pf, Biozene or Bio-cure B @ 5 g /1 litre of water.

4. **Common bean Mosaic** – This disease affects the leaves and later leaves and stipules swell and plant become stunted and produce less pods.

   Management

   a. Burning the infested plants.
   b. Sowing of diseases free seeds.
   c. Adopt crop rotation.

15. Okra (*Abelmoschus esculentus*) [Code No. – 87]

India is a leading producer of Okra in the world. Okra contain rich source of dietary fiber, minerals and vitamins. It is cultivated in tropical, sub-tropical and warm temperate region around the world.

Climate:

Okra requires warm humid weather for its growth. Germination of seeds will be zero/nil if the minimum temperature goes below 20°C. However the optimum temperature range for its growth is 20° - 30°C.

Soil:

Okra can be grown in sandy loam to dry soils. It thrives best in fertile, well drained soils.It prefers slightly acidic soils with a pH range of 5.8 – 6.5.

Varieties:

Pusa sawani, Pusa Makhmali, IHR 20-31, Parbhani Kranti, Arka Anamika, Akra Abhay, Perkin Long Green.

Field Preparation:

The land should be properly ploughed to a depth of 8-10 inches. The soil should be made friable and loose followed by leveling. FYM @ or compost @ 15-20 t/ha should be incorporated to the soil at least 30 days before sowing of seeds. Bio-fertilizers like Azospirillum @ 2 kg/ha mixed with 20 kg of FYM can be applied into the soil. Maximum moisture content should be conserve in the field ahead of sowing.

Seed Rate: 10 - 12 kg/ha.

Spacing: Plant to plant – 15 – 45 cm
Row to Row – 30 – 45 cm.

Organic Nutrient management – 15 – 20 t/ha well decomposed farm yard manure along with neem cake @ 22 g/sq meter should be applied during the land preparation. Organic nutrients should be spread evenly throughout the planting area and mixed well with 3 – 4 inch of top soils.

Sowing:

Before sowing, seeds should be treated with *Trichoderma* @ 1g/kg of seeds to reduce damping off of plants. Seeds can be sown directly into the prepared land at a depth of 2.5 cm.

Irrigation:

Irrigation is required if there is dry spell or draught during sowing time. Sufficient soil moisture should be present during flowering and fruiting time. However, excess water is harmful to the crop during rainy season. Hence, proper drainage is essential to prevent disease incidence.

Weeding:

Weeding should be done at 10 – 15 days intervals during the early stage. Mulching can be done as it helps to conserve moisture nutrients and prevents weed growth.

Insects:

1. **Root Knot Nematodes** – Crops infested by this pest are usually stunted and appear unhealthy with elongated, round swellings on the roots.

Management:

a. Application of Neem cake or saw dust @ 2.5 t/ha is advisable.
b. Soil solarisation can be practiced.
c. Crop rotation with maize, etc. can be done to reduce nematode population.
d. Marigold can be planted in the okra field.

2. **Shoot & Fruit Borer** – This pest is more prominent at the early growth and fruiting stages. It causes heavy loss to the fruits if left un-treated.

Management:

a. Maize can be grown as border crop to act as a barrier for the entry of shoot borers and fruit borer adults.
b. Installation of yellow sticky traps to attracts white flies.
c. Spraying 2 – 3 times with Nimbicidine @ 6 – 7 tsp/16 liters of water.
d. Spraying 2 – 3 times with *B.bassiana* BT @ 1 tsp/1 liter of water.

3. **Jassids** - The leaves of the plants become cup-shaped and curling after the attack of the adult and nymphs.

Management:

a. Spraying of Nimbicidine @ 6 – 7 tsp/16 liters water for 2 – 3 times at interval of 15 days helps to control the pests. Spraying should cover lower surface of the leaves.
b. Spraying 2 – 3 times with *B.bassiana* BT @ 1 tsp/1 liter of water.

4. **Aphids** – Both adult and nymphs suck the cell sap from the leaves of young growing branches. They leave sticky material on the leaves forming black fungus. This condition reduces photosynthesis activity and the plant becomes very weak.

Management:

a. Spraying of *Beauveria bassiana* or *verticillium lecanii* @ 1 tsp /1 liter of water is advisable for at least 2 – 3 sprays at an interval of 15 days.

5. **Blister Beetle –** The adult beetle can eat away the flowers completely. They also feed on the tender pods and buds.

Management:

a. The adult beetles can be collected manually and destroyed.
b. Spraying of *Beauveria bassiana* or *verticillium lecanii* @ 5g/1 liter of water at the time of flowering is helpful.
c. Wood ash can also be used to repel the insects.

Diseases

1. **Yellow vein Mosaic** – This viral disease show prominent yellowish of veins. Plants infected in the early stage remain stunted. The infected fruit turned pale yellow, deformed and tough in texture. This disease is usually carried by white flies.

Management:

a. The resistant varieties should be grown.
b. Early sowing of crops can avoid infestation of the disease.
c. The infected plant parts should be removed and destroyed.
d. Application of Nimbicidine @ 6 – 7 tsp/ 16 liters of water is advisable.

2. **Powdery Mildew** – The infected leaves show greyish powdery mass at the upper surface. In severe case the leaves turn yellow and drop off.

   Management:
   a. Late planting should be avoided.
   b. The plants left after harvesting should be burnt.
   c. Spray of 2-3 of sulfex @ 3 kg /ha in 1000 liters of water can be done after the appearance of the disease
   d. Application of ground sulphurs @ 30 kg/ha is also effective.

3. **Cercospora leaf spot –** This causes brown, irregular spots with sooty black angular spots to the leave. The affected leaves roll, wilt and fall off.

   Management:
   a. Removal of severely infected plants should be done.
   b. The plant should be sprayed with *Trichoderma* & *Pseudomonas fluorescens***.** @ 5 kg/1 liter of water.

Harvesting – The okra pods should be harvested while they were immature and green. Delay in harvesting causes poor edible quality of fruits. The pods may be cut form the plant with a knife or snapped off by hand. Harvesting should be done during morning or evening as pods loses moisture quickly after harvesting. Harvested pods should be handled carefully to avoid bruising.

16. Chayote (*Sechium edule*) [Code No. – 89]

Family: Cucurbitaceae
Khasi Name: Piskot
Garo Name: Sikot
Other Name: Chow chow
Uses:

The fruits of chow-chow are a rich source of carbohydrates, proteins, fat, minerals and vitamins, particularly vitamin A and vitamin C. It is the cheapest vegetable of North Eastern region. The pear-shaped fruit has a delicate squash like flavour when cooked and is considered to be an important item of daily diet among the people of hilly areas. Sometimes this vegetable is used as a substitute for potato and is cooked in many ways. Owing to its carbohydrate and minerals content, chow-chow fruits can also be used for preparation of pickles, candy and flour products. The leaves are also used to make tea. The woody stems furnish a fine fibre. Fruits, vines and tubers are also excellent fodder for livestock. Considerable variations are found in chow-chow in respect of fruit size, shape, colour, presence of spines and fibre content of the fruits.

The crisp texture of the vegetable is what is most favourable, it has many health benefits and nutritional values. The fruit, stems, young leaves and even the tubers are eaten either steamed or boiled in stews, baby food, juices, sauces and pasta dishes. Chayote leaves have been used to treat kidney stones, arteriosclerosis and hypertension. The fruit of chayote plants is light green with smooth skin, pear shaped and low in calories with a fair amount of potassium. Chayote squash is available from May through December, although due to its increased popularity, more stores are carrying it year round.

Benefits of Chow Chow

In case of rashes in the skin, the chow chow raw pulp is used as external application as it calms the rashes.
Leaves are also useful for treating boils on the skin. Further the leaves can be roasted and applied to burns.
The fruits and leaves have many health benefits. They are also good for the heart and keep it healthy.
The leaves can also help to lower the blood pressure.

Soil: Chow chow best survives in acidic soils and the ideal pH for its cultivation is 5.5-6.5. The soil should be well drained and rich in nutrients. Waterlogging should be avoided. Any kind of good soil can be used for the farming of chow chow.
Climate: The ideal temperature for the cultivation of chow chow is 18-22 degree Celsius. Too much heat or too cold is not suitable for growing chow chow plants. The best altitude for growing the plants would be 1200-1500m.

Propagation Methods: The propagation methods for cultivation of chow chow is mainly by the large seed which has the unusual property of germinating while still inside the pear-shape fruit. The seeds must be selected carefully and only healthy and disease free seeds must be collected for cultivation.

Planting Methods: For planting, pits must be must be dug beforehand in the field with a dimension of 2 feet and 1.5 feet and they must be exposed to the sun. After a month, the pits must be filled with a mixture of decomposed manure and topsoil. The seedlings must be transplanted when the root system has developed well. In the nursery, the seedlings are grown under protected conditions. After transplanting, the soil around the stem must be pressed firmly. This should be done so that there is no space for insects to enter inside. After planting, a light irrigation must be given to the plant.

Spacing and Planting Season: A proper gap of 8-10 feet must be given for chow chow cultivation. The spacing may vary for rainfed and irrigated conditions of farming. Proper spacing is necessary as it helps in proper growth of the plants. In each pit, about 2-5 plants can be planted in a single pit. Later, thinning can be done to keep the healthy plants and sort out the weaker ones. The number of pits for chow chow cultivation is about 500-700 pits per acre of land. The most suitable months for the planting of chow chow is April -August.

Pest and Diseases: The most common pests and insects affecting the chow chow crop are Worms, Aphids and Hoppers which can be control by spraying of *Beauveria bassiana* or *verticillium lecanii* @ 1 tsp /1 liter of water. There are only few diseases of the chow chow crop.

Yield: Depending on the variety used and proper crop management techniques, yield is 25 – 35 tonnes of fruit /ha.

Harvesting: The chow chow plants are ready for harvest in about five months' time. The plants continue to give fruits for five months. The fruits must be harvested when they are mature. They can be harvested once in every seven days.

Post Harvest Management : After harvest, the mature fruits must be cleaned and stored properly. The fruits must be sorted out and graded based on their size and quality and stored properly so that they are not damaged.

17. Kitchen Garden [Code No. – 38]

Introduction

It is an art of growing vegetables on a small piece of land in a planned way in the vicinity of living / residential house to meet the needs of the family with fresh produce all year round regularly. A successful vegetable gardening is not accidental. It is the result of proper planning, constant care and the will to grow healthy vegetables.

WHY TO HAVE A KITCHEN GARDEN?

There may be many reasons to have a Kitchen garden but some of the reasons are:

- ✓ Fresh air
- ✓ Place for exercising
- ✓ Healthy vegetables which are fresh and rich in vitamins and minerals.
- ✓ Help in family budget and saving.
- ✓ Moreover it helps us to avoid visiting Doctors 'coz by having all the fresh fruits and vegetables in our garden makes us more healthy.
- ✓ As fresh and quality vegetables are available in the backyard, when ever needed we can save time and need not go and buy from the market.
- ✓ Self preparedness.

However, the most important reason is to **c**reate a feeling of satisfaction and enjoyment in harvesting the fruit of one's own hard work and labour.

OBJECTIVES

- ✓ Raising fresh vegetables rich in nutrients to supply the family the whole year round.
- ✓ Proper utilization of land in the vicinity of the house.
- ✓ Best utilization of time of the family members creating a passion and exercising an efficient and effective training to the children.
- ✓ Utilization of kitchen water and waste.
- ✓ Economizing the food cost.
- ✓ Utilizing the spare time in a profitable way.

TYPES OF KITCHEN GARDEN

- ✓ Exclusively vegetable garden.
- ✓ Vegetable and fruits garden.
- ✓ Vegetable and flower garden.
- ✓ Combined vegetable, fruit and flower garden.

PRINCIPLES OF KITCHEN GARDENING

For developing a kitchen garden proper planning is required.

The basic principles to be considered while planning are as follows:

- ✓ In a new construction, it is wise to plan kitchen garden in advance.
- ✓ Appropriate size and shape will depend on the family size. It is better to have a small size well maintained garden than a poorly maintained large one.
- ✓ Location is the fundamental principle and it should be close to the house.

- ✓ Suitable and convenient layout.
- ✓ Open and sunny site as sunlight is very important for proper growth of plants.
- ✓ Site should be free from shade trees, etc.
- ✓ Close to well, water tap natural and any other source of irrigation including kitchen water which can be profitably utilized.
- ✓ The ideal kitchen garden should be established in a fairly high level area preferably on the southern side of the house, which can be protected by a live fence from stray animals.
- ✓ Suitable and effective rotations should be followed to make best use of the available land.

PLANNING CRITERIA

- ✓ A 200 sq. metres size plot will be sufficient to meet the demand of vegetables for an average family of 5-6 members.
- ✓ Preparation of a clear sketch plan of a planned kitchen garden on a notebook before planting should be done.
- ✓ Plan should indicate the layout of plots, paths channels, perennial plants permanent spots, etc.
- ✓ The size and shape of plots will depend on the slope of land.
- ✓ Selection of vegetables to be grown on the kitchen garden will depend on the season .region, area available .nutritive value/ importance, choice of individual's taste and preference of family members.
- ✓ Sowing /planting of vegetables should be systematically planned.
- ✓ Vegetables required in small quantities like lettuce, mint and coriander should be adjusted on ridges, along the path and water channels.
- ✓ Vegetables required in large quantities like potato, onion, garden pea, dwarf beans etc., should be allowed to occupy more space.
- ✓ Temperate vegetables like radish, carrot, turnip, etc. required for salad should be accommodated on ridges and sown continuously at intervals to make available daily.
- ✓ Climbing type of vegetables like cucurbits, French bean during summer /rainy season and garden peas in winter should be planted along the fence on the three sides along the boundary wall so that maximum space is provided for their optimum spread.
- ✓ Taking into consideration the direction of sunlight, tall vegetable varieties should always follow medium and then dwarf ones so as every plot gets maximum sunlight.
- ✓ Perennial vegetables like asparagus; cho-cho etc. should always be planted in one corner so that they do not interfere with preparation of land, annual beds, more so to avoid shade.
- ✓ Follow principles of crop rotation.
- ✓ Several sowings or succession of planting of one particular vegetables of short interval should be done to ensure regular supply of fresh vegetable, using a continuous crop pattern in the form of succession and companion cropping.
- ✓ Leguminous vegetables like French bean, pea etc., should be included in rotation to maintain soil fertility.
- ✓ Ridges should always be used to grow root vegetables and side path be used for growing tomatoes, or other leafy vegetables like celery etc.

- ✓ Early maturing varieties should be planted together in continuous row so that the area may be available at once for planting late varieties.
- ✓ The interspace of vegetables which are slow growing and take long duration to mature like cabbage, brinjal cauliflower, broccoli etc. must be used for quick growing vegetables like coriander, radish spinach lettuce etc.
- ✓ Vegetables which can be easily grown with less effort, less expensive should be included.
- ✓ A small pit in a corner of the kitchen garden may be dug so that kitchen / house waste and plant refuse, etc. be put for preparation of organic manure. This helps in providing manure for kitchen garden.

CONCLUSION

Kitchen garden should be part of home and hobby irrespective of the fact that it is developed in hills, plains, villages or cities. The idea of kitchen garden should be spread so that it can contribute substantially to the health, happiness and economy of each and every family.

18. Vegetable Seed Production:- [Code No. – 77]

Pure and healthy seeds is of great importance for successful cultivation and production of vegetable. Therefore, the best available seed must be used.

A) A good quality seed is:-

1) Healthy looking, viable and vigorous.
2) Genetically pure.
3) Bold and uniform in size.
4) Free from seed borne disease organisms.
5) Free from weed seed and other crop seed.
6) Free from dirt and any other material which may impair the quality of seed.

Definition of terms:-

1) **Kind** – It represents all those plants which are used and accepted as a single vegetable such as cauliflower, tomato, etc.
2) **Variety** – A variety in the plant world refers to a specific, individual identity within a larger plant family or species.
3) **Strain** - strain refers to variations found within plant cultivars. It also refers to the offspring that descend from modified plants. These plants are either produced by biotechnological methods or through regular breeding.
4) **Improved seed** - Seed substituted for another seed of poorer quality. It is constituted by both genetics and physical characters:
   a) Genetic Characters:-
      i. It produces higher yield than the local (or parenting used) varieties by at least 10-15%.
      ii. It is generally resistant to pest and diseases etc.
      iii. Free from seed borne diseases.
   b) Physical Characters:-
      i. Free from other varieties of the same crop or other crops.
      ii. Good germination.
      iii. Uniformity of seeds in size, colour and weight.
6) **Hybrid seeds -** A hybrid is the progeny (offspring) of a cross made under control condition between two or more strains of different parentage with different characters
7) **Nuclear seeds (original seeds) -** It is the initial quantity of a pure seed of an improved variety available with the breeder. It is genetically 100% pure where more than one variety of the same crop is to be sown for the production of nucleus seed. Proper isolation distance should be maintained for the purity.
8) **Breeders Stock Seeds -** These are the seeds of the progeny raised with nuclear seed on the seed multiplication farm.
9) **Foundation Seeds -** This is the named given to the seed of the progeny raised with breeders stock seed on the seed multiplication farm.
10) **Registered seed -**It is the progeny of the foundation seed raised on land of private growers selected for this purpose. In this seed the genetic identity and purity is maintained as certified by the certifying agency.

11) **Certified Seed -** It is the progeny of foundation and registered seed i.e., produce in such a way so as to maintained satisfactory genetic identity and purity that has been approved and certified by the certifying agency.
12) **Isolation distance –** It can be determined according to the mode of pollination of the vegetable crop which can be divided into two groups:-
    a. Self-Pollinated
    b. Cross Pollinated

Vegetable of self-pollinated crops can be grown on the same farm without any out-crossing. Without any danger of out-crossing these included crops like beans, tomato, potato, peas, lettuce etc. In cross pollinated crops which includes most of the temperate vegetables crops like cole crops. Any two of these groups cannope grown close together on the same farm because they are easily crossed. To avoid such crossing crops are sown at some distance so that they may not cross with one another. This distance is known as isolation distance and it varies from different vegetables as given below

Carrot - 540 m
Cabbage and Cauliflower – 400 m
Brinjal, turnip, tomato, chillies – 400 m
Raddish, cucumber and onion – 300 m
Lettuce – 100 m

13) **Annuals -** Crop plants that complete their life cycle from germination to seed formation in one season are called annuals eg. tomatoes, capsicum, peas, cucumber, lady's finger etc.
14) **Biennials** - Crop plants that complete their life cycle into two seasons. In the first season they grow vegetatively and store food. In the second season the plants used the stored food and form flowers and seeds.eg cauliflower, cabbage, knoll khol, turnip, carrot, beet etc.
15) **Perennials -** these crops complete their life cycle in more than two seasons.

Important Principles of vegetable seed production - Raising of vegetable seed is a highly specialised job and required intimate knowledge of crop management, protecting out crop crossing, curing, processing and storage. From seed production point of view the following principles are important for producing quality seeds:-

1) **Maintain proper isolation distance -** According to the method of pollination the vegetable crops are divided into self and cross pollinated. Self-Pollinated crops are tomato, chilli, brinjal, beans etc. Cross pollinated crops are cole crops cucumber, turnip, knolkhol, carrot, onion, garlic etc. Therefore, maintenance of proper isolation according to mode of pollination is very essential (400-800 metre isolation distance is required)
2) **Rouge out off types -** Remove off types plants or plants which are un-like parents and also other undesirable plants. Rouge out off types in stages as and when they are noticed. Rouging must be completed before crop comes into flowering especially in cross pollinated crops.
3) **Storing Seeds -** The seeds lose their germination power if they are not stored properly. The moisture content of seed is an important factor to remember. Take care to dry the seeds thoroughly before storing. Keep the dried seed in air tight container in a cool dry place.

4) **Renewing Stock Seeds -** The seed get contaminated gradually after cultivation for a number of years. Hence, renew the stock seed after every 3 - 4 years. The nucleus seed should be obtained from reliable seed dealers or Research Station.

Classification:-

There are two main groups of vegetables from the seed production point of view i.e. tropical and temperate. Seeds of tropical vegetable crops can be produce in the plain and lower hills of our country. But in the second group of vegetable which includes European vegetable temperate climate is required for successful seed production. The seeds of the latter groups where previously imported from abroad but now these seeds are produced within the country mainly in Kashmir and Kulu Valleys. The seeds of late cauliflower (belonging to the late groups) where previously not produce in India but now it is possible to produces these seeds in Kulu Valleys and near Solan.

1) COLE CROP

CABBAGE AND KNOL KHOL:-

The seeds of cabbage can be produced in hills at an elevation of 1500 m or above. There are two distinct method of seed production-

1) Seed to seed or in situ method
2) Head to seed method or transplanted method.

In seed to seed method, seed crop is raised on the same location where it is sown originally without any disturbance whereas in transplanting method the plants or roots or bulbs when matured are uprooted and transplanted in a new location, with or without storage for sometimes as the case maybe.

Advantages of seed to seed method:-

1) It avoids extra cause of cultivation in lifting and transplanting.
2) It usually gives higher seed yield in compared to transplanted method.
3) It imparts early maturity thus providing ample time for cultivation for next crops.

The only major disadvantage of seed to seed method is that system of roughing is not possible and true to type of the root crop cannot be accurately determined without lifting. It is however only desirable to raise nucleus seed of all biennial crops by transplanting method by following appropriate procedures.

In India the seed of these crops is produced in hills because plants do not bolt until they have grown for at least 6-8 weeks at temperature of 4 - 7°C. Three methods are suggested for seed production of cabbage.

1) **Late Planting -** When seedling are transplanted in late September the plants grow without forming typical heads and bolt to seed in the following spring. This method gives heavy seed yield but stock seed used must be of highest quality otherwise it is quite risky since proper selection and affective rouging is not possible.
2) **Stump Method -** The fully matured heads after selection for their true type and cut off just below the base. The beheaded position of the plant called the stump. The heads are

marketed and the stumps are either left in situ or replanted during autumn season. The following spring after the dormancy is broken the buds sprout.

3) **Stump with central core intact method -** Instead of removing the whole heads they are chopped off on all sides with downward perpendicular cut in such a way that the central core is not damaged.

The seeds of Knol Khol are usually raised in situ method. Three types of plants are usually observed, determined by the extent of the shoots. They are:-

1) None branched
2) Intermediate
3) Fully branched

The fully branched plant in a seed plot gives higher yield. There is however an appreciable difference in the quality of knobs. Knobs produced by the seeds can be harvested from any of these three types but it is important to rouge out inferior plant of Knol Khol and only well develop true to type knobs are selected.

Crops inspection and rouging (Cabbage and Knol Khol):- The crops should be inspected before the marketable stage. Off type plant can be rouge out on the basis of shape of head, colour and maturity time of head. The plants are selected based on head shape, free from seed borne disease, infestation of pest and for lower number of wrapper leaves. A minimum of three inspections should be made, 1st before the marketable stage of heads, 2nd when the head have been formed and 3rd at the flowering stage.

Isolation

Cabbage and Knol Khol being higher cross pollinated crop required isolation from the field of the varieties of the same variety, the isolation distance required is 1600 m for foundation and 1000 m for certified seed.

Harvesting and threshing:-

When the seed become brown harvesting can be started to avoid shattering. The seeds maybe harvested in 2-3 lots.

The early plants are harvested first and the remaining is harvested when about 75% of the pods are yellowish brown, harvested crop is collected and kept on threshing floor in heap for 4-7 days. Everyday, the heap is turned up and down, after curing the seeds is threshed and separated from the straw. The seed is thoroughly dried in the sun and processed.

Seed Yield - Seed yield have been found to vary considerably from place to place depending upon climate, soil, crop management factors etc. Average seed yield of cabbage is about 780 gms/ha for early crop and 1300 gms/ha for late crop. The average yield of knol khol is 1125 gms/ha.

2) ROOT CROPS

Most commonly grown root crops in our state are carrot, radish and turnip. These crops are classified into two distinct groups from seed production point of view. These are:-

1. Annuals or Tropical
2. Biennials or Temperate

The annuals can be grown for seed in the plains but the biennial produce seeds only under temperate climate. The temperate types undergo dormancy or rest period which can only be broken when the root is subjected to a low temp. i.e. less than 10°C for a period of 4-6 weeks.

Method of seed production:-

Both seed to seed and root to seed methods are used for seed production. The 2nd method is more popular for commercial production. Moreover, in seed to seed method attack of root rot is usually high.

Selection and rouging:-

Off type plants on the basis of foliage characters should be removed from the field itself before the roots are pulled out. True to type roots are identified after lifting roots from the fields. Roots not confirming to the variety are rejected. In case of carrot the central core colour and its size are the important character representing the variety. Small, bad shaped, diseased and undesirable roots should be discarded. True to type roots are selected, leaf tops are cut without damaging the base of the leaves and root tips are removed to prepare steckling.

Plant Population Density

The optimum plant spacing is must for proper growth of the plant to harvest maximum seed yield. Yield and quantity of seeds are the consequence of growth habit of mother plant. Normally seeds harvested from the thickly populated crops shall be under size, weak and poor in quality.

The optimum spacing recommended are as follows:-

1. Carrot – 45 x 30 cm
2. Radish – 60 x 45 cm
3. Turnip – 45 x 15 cm

Field inspection

A minimum of two inspections should be made. The 1st inspection shall be made after 20-30 days of seed sowing and the plants are identified and uprooted on the basis of foliage characters and transplanted. The 2nd inspection shall be made to ascertain purity of the variety on the basis of internal and external characteristics of the roots. Any plant not confirming to the marital purity should be rejected before flowering and off type plant should be removed. The subsequent inspections should be made during flowering and at maturity to verify the uniformity. Extra early or late bolters and off type plants should be removed.

Harvesting and Threshing (60 - 70 % maturity)-

In case of turnip the pods should be harvested when they turned yellow brown in colour to avoid shattering. In case of radish where shattering is not a problem, the pods are harvested when they are fully ripped. In case of carrot harvesting should be done in 2-3 phases according to maturity.

Yield:-

Carrot- 6-8 quintal / ha
Radish – 4 quintal / ha
Turnip – 5-6 qt / ha

3) PEA

Pea plant is a herbaceous annual with trailing, climbing or dwarf growth varieties. The plant is self-pollinated and therefore very little natural crossing occurs.

Isolation:- Being a self-pollinated crop it requires little isolation. In the production of foundation and certified seed the pea seed field should be isolated from the field of other varieties by 10-15 cm respectively.

Field inspection and Rouging - A minimum of three inspection is required. The first before the flowering, the 2nd at flowering and the 3rd at the edible pod stage.

Harvesting:-

In other to avoid lost from shattering crop should be harvested when the first 25% pods are ripen and the majority of the pods are matured.

The harvested vines are piled up for curing for 3-5 days. After curing, the seed is separated by threshing and they are further cleaned to make it free of dust and other materials.

Yield:- 10-12 q / ha

4) TOMATO:-

General practices for growing tomato for seed production purpose are similar to those of the market crop. It is a one season crop, sensitive to frost and required a varied temp. of 18-27°C for proper growth and development and fruiting. Fruit and seed setting is adversely affected by high temp. and low humidity.

Pollination and Isolation:-

Tomato is predominantly a self-pollinated crop, but crossing takes place to some extent. Seed field of tomato should be isolated from the field of other varieties by 50 m for certified seed and 15 m for foundation seed.

Field Inspection and Rouging:-

The crop grown for seed production should be inspected at least three times during the crop season. The 1st inspection is conducted during the vegetative stage on the basis of foliage and plant type character. The 2nd inspection maybe at flowering and fruiting stage. Shape and colour of the matured fruits is the basis for identification of true type plant. The 3rd inspection is at the time of maturity for the shape and size of the fruit. Plant showing early blight leaf spot and mosaic symptoms are removed.

Picking of fruits - Fruits turning red ripe and over ripe stages are found to be good for extracting good quality of seeds. Picking at the matured green stages should be avoided for seed production.

Extraction of Seeds:-

1. Manual extraction.
2. Fermentation method - In this method the selected ripen fruits are harvested from plants and allow to ripen further for a day or two in an earthen pot. These are then crushed well by hand or by any mechanical method to make paste. No fruit juice should be allowed to drain out before the seeds are extracted.

19. Ginger *(Zingiber officinale)* [Code No. – 29]

Background

Ginger is an important member of the Zingiberaceae family. It is one of the important cash crops and spices grown in this region due to its distinct flavour and pungency. It is used in culinary preparations, pharmaceutical preparations, as a flavourant in soft drinks, alcoholic and non-alcoholic beverages, and as confectionary, pickle, etc.

In northeast India, Meghalaya tops the list of ginger producing states; other states like Mizoram, Nagaland, Manipur and Assam also produce substantial amount of ginger. Since there is minimum use of agro chemicals in the NER, organic ginger and its value added products like ginger powder, ginger oil, ginger ale, candy, beer and wine, etc. have immense potential for economic exploitation.

Climate

Ginger is a tropical crop and is cultivated from sea level to altitudes of about 1500 m ASL. However, the optimum elevation for its successful cultivation is in the range of 300-900 m ASL. Moderate rainfall at sowing time till the rhizomes sprout, followed by fairly heavy and well-distributed showers during the growing period and dry weather about one month before harvesting are optimum requirements for its successful cultivation.

Soil

A rich soil with good drainage and aeration is ideal for ginger cultivation. Ginger grows well in sandy or clayey loam, red loam and lateritic loam soils. Effective drainage is absolutely necessary for the prevention of disease. Ginger should not be grown on the same site, year after year.

Growing Season

The planting season for ginger is from March-April, with the onset of the monsoon.

Crop Duration

The crop duration is generally around 9-10 months (March / April to December / January / February). Ginger starts flowering during the month of June-July along with the showers or rains.

Maintenance of Buffer Zone For Organic Cultivation

In order to cultivate ginger organically, a buffer zone of 5-10 m should be left all around to separate the plot from conventional farms. The produce from this buffer zone should not be treated as organic. Being an annual crop, the conversion period required will be two years.

Varieties

The high yielding varieties are Nadia, Varada and Wynad and the traditional varieties are Sying Makhir and Sying Khmoh.

Seed Selection

Carefully preserved seed rhizomes, free from pests and diseases, collected from organically cultivated farms having high yielding potential should be used for planting.

Seed Rate

Seed rate varies from region to region and with the method of cultivation adopted. However, the average is 1500-2500 kg per ha. The weight of the seed rhizomes is approx. 25-30 gm and 4-5 cm length in size.

Seed Treatment

Seed treatment induces early germination and protects from seed borne pathogen, pests and diseases particularly rhizome rot. The cut end of the seed may provide entry to fungal pathogens and to prevent this the cut seeds are dipped in a mixture of *Trichoderma harzianum* @ 2.5 gm + *Pseudomonas florescens* @ 5gm per litre of water for 30 minutes and dry under shade before sowing.

Land Preparation

While preparing the land, minimum tillage operations may be adopted. Beds of 15 cm height, 1 m width and of convenient length may be prepared, giving 45 cm spacing between beds.

Sowing Methods

Seed rhizomes may be put in shallow pits of 5 cm depth at a spacing of 20-25 cm within and between rows. Under ideal condition, germination of ginger takes place 10-15 days after planting, but it may prolonged up to two months.

Manuring

At the time of planting, well decomposed FYM / compost @ 25-30 tonnes/ha has to be applied either by broadcasting over the beds prior to planting or applied in the pits at the time of planting. Application of neem cake @ 2 tonnes/ha at the time of planting helps in reducing the incidence of rhizome rot disease/nematode and increasing yield. Soil application of *Trichoderma* bio-control agent (2.5 kg mixed with 100 kg FYM and then kept in shade for seven days) 10-15 days before sowing also helps in improving the soil biological activity. Soil application of Biofertilizer @ 30 kg/ha or seedling application @ 20 gm/litre improves yield.

Managing Soil Fertility

Mulching the ginger beds with green leaves is an essential operation to enhance germination of seed rhizomes and prevent the soil from running off due to heavy rains. It also helps to add organic matter to the soil and conserve moisture during the later part of the cropping season.

The first mulching with green leaves @ 10-12 t/ha is at the time of planting. It is repeated @ 5 t/ha at 40 and 90 days after planting. Cow dung slurry or liquid manure may be poured on the bed after each mulching to enhance microbial activity and nutrient availability.

For the management of soil fertility, incorporation of leguminous crops like soybean, french bean, pigeon pea, etc., besides improving soil fertility, are income generating crops and have a good market demand. Use of wood ash in the field also increases the potash content of the soil.

Earthing Up

Soil stirring and earthing up are essential for enlargement of daughter rhizomes and it also provides adequate aeration for roots and protects the rhizomes from scale insects besides helping in weed management. The first earthing up is done at 45th day after planting and second at 120-135 days after planting.

Cropping System

Ginger can be grown as sole crop or intercropped with vegetables, pulses, cereals, oilseeds and other crops. Intercropping with soybean, finger millet and maize is advantageous. It is a nutrient exhaustive crop and so crop rotation with nutrient supplementing crops is preferred. Crop rotation with tomato, potato, chillies and eggplant should be avoided as these are hosts of the wilt causing organism (*Ralstonia solanacearum*). Leguminous crops / vegetables like different beans and cucurbits are suitable crops for rotation and as cover crop.

Harvesting

The crop is ready to harvest in about eight to ten months depending upon the maturity of the variety. When fully matured, the leaves turn yellow and start drying up gradually. A properly managed crop gives an average yield of 20 t / ha.

Cleaning

Cleaning of harvested ginger is usually done by hand. After the soil particles are removed and the mother rhizomes separated, the harvested ginger is kept in the sun for drying from few hours to a day and then kept on raised wooden / bamboo platforms inside the shed, either for seed or for sale.

Storage of Seed Rhizomes

Duration between first harvest and next planting is 120-150 days. Therefore seed rhizomes should be stored to reduce rotting, shriveling and dehydration and sprouting can be avoided until the next season. Storage losses can often be as high as 10-50 per cent. The cheapest storage structure and easy method for construction which is also being practised at the Ginger Development Station, Umsning is very important to encourage the farmers to adopt this technique of storing Ginger seed rhizomes. The method for construction is as follows:-

Materials required:

1. Bamboo / bamboo mats
2. Cowdung
3. Mud (Clay + Water + Cowdung)
4. Paddy straw
5. Dried leaves / polythene sheet

Method of construction

1. Two chambers of 2m x 2m square and 1.4m height from the ground level.
2. The walls of the chamber are made of bamboo mats, and then plastered with clay and cowdung paste.
3. The two bamboo mats are made to stand straight and parallel at 20cm apart with the support of the bamboo post.
4. Paste of clay and cowdung was poured in between the mats in 4-5 stages with a one day interval up to a complete height (1.4m) of the walls and dry for 20-25 days.
5. The outer surfaces of the mat were plastered with clay and cowdung paste and allowed to dry completely.

Method of storage

1. The ginger was stored in a chamber made by alternate layers of dry paddy straw and rhizomes keeping the thickness ratio of 2.5:10 cm.
2. The lower and upper layer of paddy straw was kept around 8cm thick.

3. The top of the chamber was covered with the polythene sheet and sealed from the edges by putting more pressure with the help of split bamboo.
4. Ginger can be kept for six to eight months in this structure.
5. The unit capacity of this structure is 350kg to 400kg per cubic metre of space.

Observations:

1. The outside air cannot enter or disturb the inside. So the temperature inside the storage remains the same.
2. Mud wall helps in maintaining the temperature inside.
3. The layer of paddy straw helps to circulate the air from one layer to another.
4. The same storage may be repaired by polishing it every year.

Advantages:

1. Loss due to shrinkage and loss in weight is negligible.
2. The colour, shape and size of the rhizome remain as it is at the time of storing.
3. Any affected rhizome in one layer cannot affect the rhizome of other layer. This reduces the loss affected due to soft rot.

Diseases

Soft Rot (*Pythium aphanidermatum*)

Symptoms: It is a serious seed as well as soil borne disease and the symptoms can be seen from July. Yellowing of leaves appear first on the lower leaves and proceeds to upper leaves. Roots arising from the affected rhizome become rotten and show brown discoloration of the rhizome tissue. Sometimes the pseudostem comes off easily with a gentle pull. The rotten parts attract other fungi, bacteria and insects particularly the rhizome fly. During the rainy season this disease spreads very fast from the infected field to healthy field.

Management : Avoid water logging and mother rhizome removal. At the time of sowing treat the rhizomes with *Trichoderma harzianum* or *T. viride* @ 8-10 gm / litre water or Bordeaux mixture (1%). Remove the badly affected plants and drench around the infected plants, after slightly removing of soil with *Trichoderma* @ 8-10 gm / litre water or Bordeaux mixture (1%).

Bacterial Wilt (*Ralstonia solanacearum*)

Symptoms : It is the most serious disease and the symptoms can be noticed from July-August. The leaf margins of the affected plant turn bronze and curl backward. The whole plants wilt and die. The base of the infected pseudostem and the rhizome emit foul smell. When the suspected pseudostem is cut and immersed in a glass of clean water milky exudates will ooze out from the cut end. Typical symptom is the wilting observed during afternoon in young seedlings.

Management : Seed contamination is the major sources of infection hence procure only healthy rhizome from disease free area. 3-4 years crop rotation should be followed to avoid disease incidence. Avoid crop rotation with solanaceous crops like tomato, chilli, brinjal, etc rather go for leguminous or cruciferous crops soybean, mustard, radish, etc to overcome pathogen. Seeds should be treated with *Trichoderma harzianum* or *Trichoderma viride* + *Pseudomonas florescens* @ 5-10 gm per kg seeds before sowing. Remove the affected clumps and drench the soil with *Pseudomonas florescens* @ 10 gm / litre water or Bordeaux mixture (1%).

Insect & Pests

Shoot Borer (*Conogethes punctiferalis*)

The larvae bore the tender pseudostem and reach the central portion by feeding on the internal tissues, thus resulting in yellowing and drying of shoots. Infestation may occur from June to October.

Management : Mechanical collection and destruction of adult larvae periodically. Install light traps during mid-May to June, July month for adult mass trapping. Spray Nimbicidine (2-5 ml/l) or *Beauveria bassiana* @ 2-5 ml/l.

White Grub (*Holotrichia spp*.)

It is a sporadic pest, sometimes causes serious damage. The grub feeds on the roots and newly formed rhizomes. The infestation is generally more during August-September.

Management : The entomophagus fungus *Metarrhizium anisophilae* can be mixed with fine cowdung and then applied in the field to control the grubs. In endemic areas opt for soil application of neem cake @ 40kg/ha before sowing or apply Nimbicidine @ 2-5 ml/l or *Beauveria bassiana* @ 2-5 ml/l. FYM or cowdung should be well decomposed to avoid infestation.

Rhizome Scale (*Aspidiella hartii*)

The economic part of the plant namely the underground rhizome is often attacked both in field and in storage condition. The minute crawling nymphs infest near the growing buds and suck the sap. It results in shrivelling and drying of the rhizomes. The plants are devitalized and get withered before drying completely. The rhizomes fail to germinate.

Management : Severely infested rhizomes are to be discarded before storage of rhizomes. Storage of rhizomes in dried leaves of *Strychnos nux-vomica* + sawdust in 1: 1 proportion helps in keeping the seed rhizomes free of scale infestation. Spraying of Neem oil @ 3ml/l at 15 days interval is found to be effective.

20. Turmeric (*Curcuma longa*) [Code No. – 76]

Turmeric is a sub-tropical plant and can be grown on different types of soils under rain and irrigated conditions. It is a shallow rooted crop and suitable for intercropping. Turmeric plant is propagated through rhizomes. It is used as spices in Indian foods. It has several medicinal properties like stomachic, carminative, tonic, blood purifier, vermicide and antiseptic. The active ingredients of turmeric are cur cumin, which has a wide range of therapeutic effects. It is cultivated in Andhra Pradesh, Tamil Nadu, Orissa, Karnataka, West Bengal, Gujarat, Meghalaya, Maharashtra and Assam. India is the largest producer and exporter of turmeric in the world. It can be grown in the temperature range of 20-35°C with annual rainfall of 1500 mm.

Soil – Turmeric requires rich loamy soil having good drainage. Sandy or clay loam soil with a pH range of 4.5 – 7.5 with good organic matter status. It cannot withstand water stagnation or alkaline soil.

Sowing time – April –May.

Spacing Time – 25 – 30 plant to plant & 45 – 60 cm between rows.

Seed rate – 2500 kg / ha. Each planting unit consists of bits of 20 - 25 gram each.

Varieties – Lakadong variety from Jaintia Hills is mostly grown in the state. The plant height is 140-180 cm and the leaves are shiny green. Finger rhizomes are stout and reddish and matures within 255 days. It is also highly resistant to leaf diseases. It is popular for its high curcumin content. Other varieties are Meghalaya Turmeric – 1, Surome, Roma, Alleppey, Sudharshana.

Propagation – Both whole and splits mother rhizomes are used for planting. Select well developed, healthy and disease free rhizomes for planting. Mother rhizomes are split into two, each having at least one bud. The fingers are cut into 4-5 cm long pieces.

Land Preparation – Land should be prepared to fine tilth with four deep ploughing. Beds of 15 cm height and 1 m width should be prepared at a spacing of 45 cm apart.

Seed treatment – Before panting the rhizomes are soaked in a mixture of *Trichoderma harzianum* @ 2.5 g + *Pseudomonas florescence* @ 5 g / 1 liter of water for 30 minutes. Rhizomes are stirred 3-4 times to ensure uniform soaking. Then the rhizomes are air-dried under shade. Seed treatment induces early germination and protects from seed borne pathogen, pests and diseases especially rhizome rot.

Sowing – Small pits are made with a hand hoe on the prepared beds with a spacing of 20-25 cm along the rows. Place the finger rhizomes flat with bud facing upwards in the shallow pits. Then cover the rhizomes with soil or dry powdered farm yard manure.

Organic nutrient management – Application of well decomposed FYM or compost @ 25-30 tones / ha to the land is done through broadcasting and ploughing at the time of land preparation. Apply Neem cake @ 2 tones / ha along with vermi-compost @ 10 tones / ha at the time of planting to increase yield and control rot disease and nematodes. Soil application of *Trichoderma* bio-control agent (2.5 kg mix with 100 kg FYM and keep in shade for 7 days) for 10-15 days before sowing also helps in improving the soil biological activity. Also soil application of bio fertilizer like Azosperillium @ 30 kg / ha or seedling application @ 20 g / liter of water improves yield as it supply better nutrition to the crop.

Mulching – Paddy straw or green leaves are usually used for mulching in turmeric beds after sowing. This will help to enhance germination of rhizomes and it prevents soil erosion during

heavy rains. It also helps to add organic matter to the soil and conserve moisture during the later part of the cropping season. The first mulching with green leaves @ 10-12 tones / ha is to be done immediately after sowing. Then it is repeated @ 5 tones / ha at 40 and 90 days after planting. Cow-dung slurry or liquid manure may be poured over the beds after each mulching to enhance microbial activity and nutrient availability. Mulching helps to reduce weed growth in the beds.

Weeding & earthing up – Weeding should be done thrice at 60, 90 and 120 days after sowing depending upon the weed intensity. Earthing up is essential for the enlargement of rhizomes and it is also provide adequate aeration to the roots and protects the rhizome from scale insects. The first earthing up is done at 45 days after planting and the second at 120 – 135 days after planting. Earthing up also helps to manage the weeds growth.

Cropping system – Turmeric can be grown as intercrop with leguminous crops like soya-bean, French-beans, pigeon pea etc. Intercropping with soya-bean and finger millet and maize is advantageous as it improve the soil fertility.

Harvesting & curing – Turmeric takes 7-9 months for harvesting. Drying up of the aerial portion indicates maturity. An average yields of 25-30 tones / ha of fresh rhizomes may be obtained. After harvesting the fingers are separated from the rhizomes. Then they are cleaned and dried for one day.

Processing – The rhizomes should be boiled in water till they become soft and then dried in the sun fir 10-15 days until they produce metallic sound. The dried rhizomes are the put into the gunny bags and crushed against the floor in order to remove the scales and roots.

Storage – The fresh harvested rhizomes should be dried in shade for 4-5 days after removing the dirt and leaves. Then they are kept in an underground pit. The upper layer of the rhizome should be covered with dry grass and the month of the pit may be covered by plastering it to prevent water from entering into the pit. The pits should be opened during January – February to inspect diseases infestation of rhizomes.

DISEASES

1. **SOFT ROT** (*Pythium aphanidermatum*)

   Symptoms: It is a serious seed as well as soil borne disease and the symptoms can be seen from July. Yellowing of leaves appear first on the lower leaves and proceeds to upper leaves. Roots arising from the affected rhizome become rotten and show brown discoloration of the rhizome tissue. Sometimes the pseudostem comes off easily with a gentle pull. The rotten parts attract other fungi, bacteria and insects particularly the rhizome fly. During the rainy season this disease spreads very fast from the infected field to healthy field.

   Management : Avoid water logging and mother rhizome removal. At the time of sowing treat the rhizomes with *Trichoderma harzianum* or *T. viride* @ 8-10 gm / litre water or Bordeaux mixture (1%). Remove the badly affected plants and drench around the infected plants, after slightly removing of soil with *Trichoderma* @ 8-10 gm / litre water or Bordeaux mixture (1%).

2. **Bacterial Wilt** (*Ralstonia solanacearum*)

   Symptoms: It is the most serious disease and the symptoms can be noticed from July-August. The leaf margins of the affected plant turn bronze and curl backward. The whole plants wilt and die. The base of the infected pseudostem and the rhizome emit foul smell. When the suspected pseudostem is cut and immersed in a glass of clean water milky

exudates will ooze out from the cut end. Typical symptom is the wilting observed during afternoon in young seedlings.

Management: Seed contamination is the major sources of infection hence procure only healthy rhizome from disease free area. 3-4 years crop rotation should be followed to avoid disease incidence. Avoid crop rotation with solanaceous crops like tomato, chilli, brinjal, etc rather go for leguminous or cruciferous crops soybean, mustard, radish, etc to overcome pathogen. Seeds should be treated with *Trichoderma harzianum* or *Trichoderma viride* + *Pseudomonas florescens* @ 5-10 gm per kg seeds before sowing. Remove the affected clumps and drench the soil with *Pseudomonas florescens* @ 10 gm/liter water or Bordeaux mixture (1%).

INSECT/PESTS

1. **Shoot Borer** – (*Conogethes puntiferalis*) – The larvae bore the tender pseudostem and reach the central portion by feeding on the internal tissues resulting in yellowing and drying of shoots. Infestation may occur during June – October.

   Management – Mechanical collection and destruction of the adult larvae periodically should be done. Light traps should be installed during mid May to June and July to trap adults. Spray Nimbicidine (2-5 ml/water) or *Beauveria bassiana* @ 2-5 ml / 1 liter of water.

2. **White Grub** (*Holotrichia spp.*) - It is a sporadic pest, sometimes causes serious damage. The grub feeds on the roots and newly formed rhizomes. The infestation is generally more during August-September.

   Management : The entomophagus fungus *Metarrhizium anisophilae* can be mixed with fine cowdung and then applied in the field to control the grubs. In endemic areas opt for soil application of neem cake @ 40kg/ha before sowing or apply Nimbicidine @ 2-5 ml/l or *Beauveria bassiana* @ 2-5 ml/l. FYM or cowdung should be well decomposed to avoid infestation.

3. **Rhizome Scale** (*Aspidiella hartii*) - The economic part of the plant namely the underground rhizome is often attacked both in field and in storage condition. The minute crawling nymphs infest near the growing buds and suck the sap. It results in shrivelling and drying of the rhizomes. The plants are devitalized and get withered before drying completely. The rhizomes fail to germinate.

   Management: Severely infested rhizomes are to be discarded before storage of rhizomes. Storage of rhizomes in dried leaves of *Strychnos nux-vomica* + sawdust in 1: 1 proportion helps in keeping the seed rhizomes free of scale infestation. Spraying of Neem oil @ 3ml/lit of water at 15 days interval is found to be effective.

21. Black Pepper *(Piper nigrum)* [Code No. – 09]

Black pepper is a perennial climbing vine grown for its berries. The berries are extensively used as spice and in medicine. India is a leading producer, consumer and exporter of black pepper in the world. It is known as the king of spices and is being cultivated on large scale in India.

Climate and soil – Black pepper is a plant of humid tropic requiring adequate rainfall and humidity, it requires a total annual rainfall of 2000-3000 mm and a dry spell of 30-45 days before flowering with the onset of rain and humidity of 75-95% for its cultivation. It grows successfully up to 1200 m above mean sea level. The crop tolerates growth between 10-40°C. Black pepper is usually grown on shade trees like coffee, cardamon and tea plantations. Peppers prefer a light porous and well-drained soil which is rich in organic matter. Water stagnation in the soil, even for a very short period is injurious to the plant. The ideal soil pH for pepper is 4.5 – 6.0

Variety:

1. Panniyur – 1
2. Panniyur – 2

Propagation – Black pepper is propagated vegetatively from cuttings. Cuttings are raised mainly from runner shoots originating from the base of the vine and have long internodes with strike roots at each node. The selected mother plant should be in the age group of 5-15 years. It should be high yielding, possess vigorous growth with maximum number of spikes and disease tolerance. Selected runner shoots produced at the base of the mother plants should be kept in coiled and raised to prevent from striking roots in the soil.

Two nodes semi hard wood cuttings are to be planted for rooting of pepper cuttings. The cuttings should be treated with *Pseudomonas fluorescence* @ 250 g in 750 ml water for 20 minutes.

Potting mixture should be prepared by mixing two parts of fertile top soil, one part of river sand and one part of well rotten FYM in the ratio of 2:1:1. Spread this potting mixture on a leveled ground to a height of 15 – 20 cm, moisten with water and cover the soil with transparent polythene sheet. Plant the cuttings in polythene sleeve filled with the potting mixture. The polythene sleeve used should be perforated well to ensure good drainage.

The cuttings should be planted at least one node deep in the soil and be kept in proper shade. Cuttings are to be well protected from direct sunlight and frequent watering is needed to maintain a humid and cool atmosphere around the cuttings.

Planting Time – Runner shoots are separated from vine during February – March from Nursery to the field during May – June.

For planting pepper prepare pits 15 cm away from standards. The size of the pit should be 50 cm x 50 cm x 50 cm. Fill the pits with a mixture of top soil and compost / well rotten cow-dung 5 kg / pit and 50 g *Trichoderma*. The growing portions of the cuttings are to be trained and tied to the standard (1.5 - 2 m height) at the interval of 30 cm. the tying is done firmly around the nodes, the nodal region is firmly attached and pressed to climb with the standard. The line standards are used at a spacing of 2.7cm x 2.7 m. The pepper vine is allowed to grow on the stem with the lower portion kept clean and un-branch at least 1 m from the ground level. Since the pepper vine grow rapidly, the growth should be regulated by regular pruning to produce lateral branches. The plants are trimmed at the top and prevent from growing too tall for convenient picking. Pruning of

standards twice a year in March – April and July – August is also required for proper development of pepper vines.

Manuring – Apply 10 kg cattle manure/compost + 500 g neem cake + 500 g ash + 2 kg vermi-compost with *Azospirillum* in two split doses, first in May - June and second in August - September. Apply lime @ 500 g per vine in April - May.

Plant protection: -

Pests:

(a) Pollu beetle

i. Apply Neem oil + garlic emulsion 2% at spike emergence, berry formation and berry maturation stage.

(b) **Scale insects** - Three different types of scale insects are found infesting black pepper. They are black pepper mussel scale infesting all parts of vines, coconut scale feeding from under surface of leaf and soft scale confining to upper leaf surface. The infestation causes significant loss of yield.

i. Clip off and destroy severely infested branches.

ii. Spray *Verticillium lecanii* formulation 20 g per 1 lit or 5 ml per lit of water.

iii. Control should be initiated during early stages of infestation.

(c) **Root Knot Nematode** – To control burrowing nematodes use nematode free rooted cuttings. Spray and drench Pacer/Termicon/ Nematon @ 5 g/1 lit of water to the soil.

Diseases: -

Apply *Trichoderma* in nursery to prevent rotting and fungal diseases.

Foot rot and anthracnose: -

i. Remove all infected or dead vines and burn them.

ii. The organic manure used for main field planting should be enriched with *Trichoderma*.

iii. Drenching and foliar spray with *Pseudomonas fluorescence* @ 5 ml /lit of water during May - June and October.

iv. Heavy watering which causes water stagnation is to be avoided. Remove shade as soon as continuous rain sets in.

Harvesting and processing: -

The first harvest can be made during 3rd year after planting but commercial bearing starts from 6th year onwards. Duration of the black pepper varies from 20 - 25 years. Those varieties which start bearing late have a longer life-span. The harvest season extends from November to January in plains and January to March in hills. During harvesting, when one or two berries in the spike turn bright orange red, the whole spike is hand-picked.

Black pepper - Black pepper of commercial value is produced from whole, unripe, but fully mature berries. For black pepper the berries are harvested slightly early while for white pepper it is harvested at an advanced stage of ripeness i.e. when the berries turned red.

The harvested berries are piled up in a heap to initiate browning and detached from the stalk by threshing and then spread on suitable drying floor. During sun drying, berries are raked to

ensure uniform drying to avoid mould development. The berries are dried until the outer skin becomes brown-black or shrivel then the dried berries are cleaned, graded and packed.

White pepper - White pepper is prepared from fresh berries, the harvested ripe berries are detached from the stalk and packed in gunny bags. The bags are soak in slow running water for 7 - 10 days. After 10 days they put in a heap in a tarpaulin and rubbed by hands or trampled under feet to remove the outer soft skin, washed in water then sun dried to reduce the moisture content to 10 - 12 % and to achieve a cream or white colour. White pepper is graded, sorted and packed.

Yield: - The yield of black pepper varies widely depending upon several factors such as elevation, temperature, soil, rainfall etc. However, a full bearing plant may yield 2 - 3 kg of dried pepper per plant.

22. Soyabean *(Glycine max)* [Code No. – 70]

Soyabean is a tropical crop but it can be grown in sub-tropical and temperate climate too. It needs temperature range of 15°- 32° C for growth and development. Many products are prepared from Soyabean like soya milk, soya cheese, soya flakes, fermented Soyabean, soya biscuits and it can be eaten after steaming or roasting. A Soyabean plants is used as fodder for cattle and it also helps improve the soil fertility.

Soil: Soyabean can be grown in a well-drained fertile loamy soil rich in organic matter. The soil pH should be 6-6.5. The crop is sensitive to water logging.

Sowing: The land should be prepared properly with deep ploughing to minimize pest population. Fine seed bed should be made for proper seed germination.

Varieties: RCS 1-1, RCS 1-9, RCS 1-10, Clark – 63, Bragg, Hill Punjab – 1, Hardee and Lee

Seed rate – 70-75 kg / ha

Spacing – 45 cm row to row 5 - 10 cm plant to plant

Depth of planting – 3.5 - 5 cms.

Sowing time – June – July for summer crop, August to September for winter crop.

Seed Inoculation: Soyabean being a leguminous crop it can fix atmospheric nitrogen into the soil. Therefore seeds should be treated with rhizobium @ 200 gms in 200 ml water mixed for 10 kg bean seeds prior to sowing.

Cropping System: Soyabean can be grown as inter cropping with Maize and French bean.

Weed management: For the first 6 weeks the field should be weed free to optimize the efficient used of nutrients and sunlight.

Insect pest and Management:

1) **Bean leaf beetle** - This pest feeds on the leaf and pod making round holes between the major leaflet veins. It also feed on the surface of the pod, leaving only a thin film of tissue.
2) **Green stink bug-** Both adult and nymph suck the plant fluids. Stink bug feed directly on pods and seeds.

Control

i. Both beetle and stink bug can be managed by spraying *Beauveria bassiana* @ 5 g / 1liter of water.
ii. Spraying of Neembicidine @ 6 tsp / 16 lits of water.

3) **Grasshoppers and *Helicoverpa armigera***- Grass hoppers feed on the leaves starting from the margin. They may also feed on the pod. Whereas *Helicoverpa armigera* can damage the crop in all crop stages. It produces round chew marks and holes during vegetative stage. During flowering larvae feed on buds, flowers and pods. Grass hoppers can be

Control

i. *Helicoverpa armigera* can be collected and destroyed mechanically.
ii. Spraying neem oil or Neembicidine @ 6 tsp / 16 lits of water.
iii. *Beauveria bassiana* @ 5 g / 1liter of water can be sprayed to manage the pest.

i. **Leaf Roller** – This is the most damaging pest on Soyabean. The larva of this moth roll the leaf from tip downwards and feed inside tender leaf and buds. Damaged leaf have a silvery brown papery look.

Control

i. Spraying of *Verticillium lecanii* @ 5g / 1 litre of water.
ii. Install pheromone traps for mass trapping of the adults.

Diseases of Soyabean – The most prominent diseases of Soyabean are:-

1) **Damping off** – Seed may rot before emergence. Seedling may show wilt and ultimately collapse.

Control

i. Seed treatment with *Trichoderma* prior to sowing.
ii. Spray the crop and drench the soil with *Trichoderma*.

2) **Phytophthora root rot –** This disease cause damping off in the early stage of crop growth. Water soaked lesions appear on the seedlings. On stem a purple or brown discolouration from the roots to the lower nodes of the infected plant. On pulling the infected plant may come out easily.

Control

i. Seed treatment with *Trichoderma* prior to sowing.
ii. Spray the crop and drench the soil with *Trichoderma*.
iii. Crop rotation, application of well decomposed manure and avoid water logging condition.

3) **Rhizoctenia Root Rot –** This is mostly seen in seedling and young plants, causing root and stem rot particularly during prolonged wet periods. This can be a cause of pre and post emergence damping off. It produce reddish brown discolouration on the stem near the soil line. This also causes wilting and yellowing of the leaves. This pathogen is a soil inhabitant. Seeds can be treated with Rhizobium or *Azotobacter* @ 200 g mix with 200 ml of water prior to planting.

Control

i. Seed treatment with *Trichoderma* prior to sowing.
ii. Spray the crop and drench the soil with *Trichoderma*.
iii. Crop rotation, application of well decomposed manure and avoid water logging condition.

4) **Rust** – Dark brown or reddish brown pustules on the ventral side of the leaves and also on the petioles, pods and stems may appear. The leaves will become yellow and fall off.

Management & Control

i. Seed treatment with *Trichoderma* prior to sowing.
ii. Spray the crop and drench the soil with *Trichoderma* @ 5g / 1 litre of water.
iii. Crop rotation, application of well decomposed manure and avoid water logging condition.

5) **Bacterial Blight** – Red or black lesion appear on the leaves. This pathogen survived on the infected seeds and crop residue. The infected crop residue should be burnt.

Management & Control

i. Seed treatment with *Pseudomonas* prior to sowing.
ii. To manage spray *Pseudomonas* @ 5g / 1 litre of water.
iii. Crop rotation, application of well decomposed manure and avoid water logging condition.

6) **Soyabean mosaic** – This causes yellow to green mottling pattern on the leaves. It leads to distortion and curling of leaves along the margin, followed by stunted growth.

Management & Control

i. Seed treatment with *Trichoderma* prior to sowing.
ii. Spray the crop and drench the soil with *Trichoderma* @ 5g / 1 litre of water.
iii. Crop rotation, application of well decomposed manure and avoid water logging condition.

7) Powdery mildew – Appearances of powdery coating on the leaves and stem and branches of the crops. Infected leaves later drop off from the plant. To manage, we should follow crop rotation. Remove the crop residue and burn.

Management & Control

i. Remove the crop residue and burn.
ii. Spray the crop and drench the soil with Bio-dewcon @ 5g / 1 litre of water.
iii. Crop rotation, application of well decomposed manure and avoid water logging condition.

8) Downy mildew – The symptoms appear as pale green yellow spots on the upper surface of the leaves. Later the spots become dark yellow and occupy larger area on the leaves. Low temperature and cool whether favours this disease development.

Management & Control

i. Remove the crop residue and burn.
ii. Seed treatment with *Trichoderma* viride @ 4g / kg of seeds before sowing should be done.
iii. Spray the crop and drench the soil with *Trichoderma* @ 5g / 1 litre of water.
iv. Crop rotation, application of well decomposed manure and avoid water logging condition.

Harvesting: Harvesting is done when the leaves are dried and shed. Generally crop matures in 90 – 140 days depending upon varieties.

23. Multiplication & Propagation of Fruit Plants [Code No. – 49]

Temperate Fruits

Mass multiplication of planting materials is the main purpose

Fruits grown are :
Plum: Santa rosa, Japanese plum, Doris, Duffy, Alberta
Pear: Lagoon, Naspati, Fertility, William pear
Peach: Alton, Kierra, Low chilling peach
Kiwi: Alison, Hew
Apple:

Propagation Methods: Budding, Grafting, Layering and Cutting

Nursery Management

- A plant nursery is a place where planting materials are raised either by seeds or by vegetative means with care before transplanting.

Nursery Preparation

- Favourable soil condition
- In a container add equal ratio of sand clay and FYM
- In nursery beds add 3:1:1 ratio of sand clay and FYM
- Height -15-20cm
- Width- 1m
- Length- As desired
- Bed to bed- 30-40cm
- Sowing Line or broadcasting
- Light irrigation, thinning, weeding

Budding

- The process of connecting scion which is a bud with a rootstock, such that they unite and grow as one plant is termed as budding
- Best time: June, July

Inverted T-Budding

- Select a smooth skin rootstock
- Inverted T-shaped incision is made upward
- Extract the bud upward from the scion and insert in the incision on the rootstock
- Wrapped air tight using poly strip leaving the bud exposed.
- Budding is done 10-25cm height on rootstock

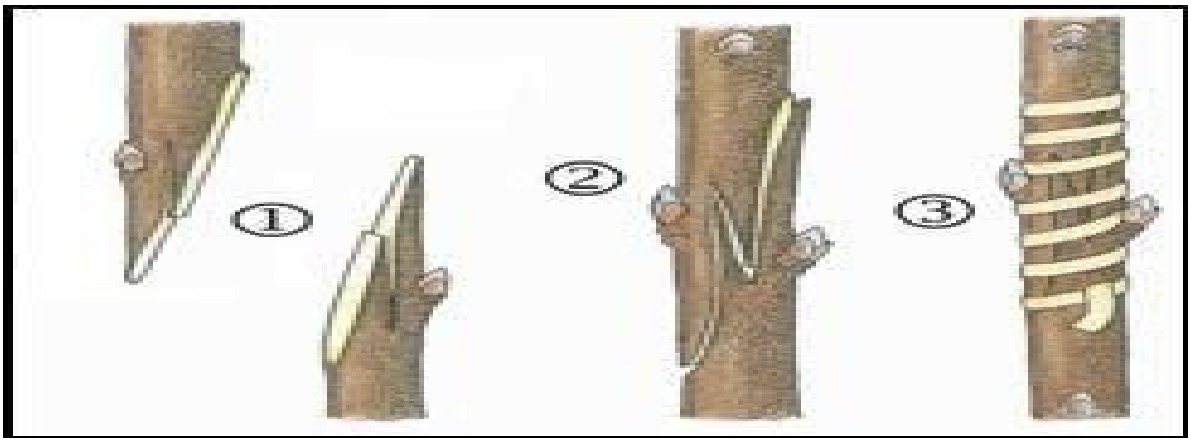



Grafting

- To unite scion and rootstock so as they grow as a single plant
- Best time: mid Nov- Feb

Tongue Grafting

- A slanting cut is prepared on both rootstock and scion
- A second cut half the length of the first cut is made downward
- The scion and rootstock are inserted which interlock each other
- The cambium layer of both should match, if not so it must match along one side.
- Cover the joint union air tight with a poly strip
- Remove the suckers below the graft union.



Layering

A portion of a plant is forced to produced adventitious roots while it is still attached to mother plant. Upon emergence, of roots, the shoot is separated from mother plant, raised in nursery for some time and the transplanted to the field.

Air Layering

Materials required: Sticky soil, Peat moss, Well decomposed cow-dung, Rope, Transparent polythene, rooting hormone (No. 2 or 3), and water.

Preparation of media: Mix the soil with cow-dung, moss and water.

Steps:

- One year old Previous season shoot of pencil size is selected
- About 5-7cm from the base of the selected shoot, a girdle of 2.5-3cm is prepared by removing the bark
- Apply rooting hormone, covered with the media
- Wrapped with polythene and both ends are tied air tight
- After 2-3 months when the roots becomes visible the layered shoot is separated from the mother plant raised in nursery with frequent watering
- Best time :July August

Cutting

- Separation of a portion from mother plant and planting it in a medium suitable for its growth to constitute a new plant is termed as cutting.
- Best time: Nov- Feb

Stem cutting

- Hardwood: ; Plant of one year old shoots are selected, Pomegranate,

Pruning

Judicious removal of plant part to obtain better yield is termed as pruning

Objectives of Pruning

- Control flowering and fruiting
- To obtain regular bearing
- To removed diseased damaged insect infested and weak shoots
- To ensure bearing shoots gets sunlight

Principles Of Pruning

- Remove water sprout
- Avoid bark injury while pruning
- Done during dormancy period

24. Management of Orchard [Code No. – 52]

1. **Selection of Site** – The selection of site is very important and the following criteria should be considered.
    a) The climate should be favourable to the fruit crops to be grown.
    b) There should be adequate supply of water throughout the year.
    c) Nature of soil and its fertility.
    d) There should be no water stagnation.

The land selected should be cleared by removing trees without leaving stumps or root. In hill areas the land should be divided into terraces and levelling is done within the terraces. If the soil is poor, green manure crops should be grown to improve its physical and chemical conditions before planting fruit trees. Adequate manure should be applied during ploughing.

2. **Planning of Orchard** – The following points should be remembered during planning of an orchard.
    a) To obtain maximum number of trees per unit area optimum spacing should be maintained.
    b) Particular fruits to be grown should be assigned in a separate block.
    c) Fruits ripening at the same time should be grouped together.
    d) In deciduous fruit trees, some varieties required pollen from another variety to set fruits. Therefore pollinators should be planted in every third tree and in every third row.
    e) Fencing should be done, live fencing is preferable as it is cheaper than any other fencing materials.
3. **Layout of Orchard** – In order to accommodate maximum numbers of trees proper layout of the orchard should be followed. There are different types of laying out in orchard.
    a) Vertical row planting system
        - **Square system -** The fruit plants are planted in each corner of a square with appropriate planting distance. This is the easiest method and most commonly followed. Inter cropping can be done in two directions in this method.
        - **Rectangular system –** The trees are planted in each corner of a rectangle. Here the distance between any two rows is more than the distance between any two trees in a row. The intercultural and mechanical operations can be carried out freely in the wider spaces.

    b) Alternate row planting pattern
        - **Hexagonal system** - In this method, the trees are planted in each comer of an equilateral triangle. This way six trees form a hexagon with the seventh tree in the centre. This system provides equal spacing, the limitations of this system are that it is difficult to layout and the cultivation is not so easily done as in the square system.
        - **Diagonal system -** This is the square method but with one more plant in the centre of the square. This will accommodate double the number of plants, but does not provide equal spacing. The central (filler) tree chosen may be a short lived one. This system can be followed when the distance between the permanent trees is more than 10 m. As there will be competition between permanent and filler trees, the filler trees should be removed after a few years when main trees come to bearing.

- **Triangular system -** The trees are planted as in square system but the difference being that those in the even numbered rows are midway between those in the odd rows instead of opposite to them. Triangular system is based on the principle of isolateral triangle. The distance between any two adjacent trees in a row is equal to the perpendicular distance between any two adjacent rows.
- **Contour system -** It is generally followed on the hills where the plants like pineapple, etc. are planted along the contour across the slope. It is particularly suitable for land with undulated topography, where there is greater danger of erosion and irrigation is difficult. The main purpose of this system is to minimize land erosion and to conserve soil moisture so as to make the slope fit for growing fruits and plantation crops. The contour line is so designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the, soil without causing erosion.
- **Terraces and Half- moon terraces system:** Terrace system refers to planting in flat strip of land formed across a sloping side of a hill, lying level along the contours. Whereas half-moon terraces are made by cutting in half moon shape to create circular level bed having 1-1.5 m diameter. This also provides facilities for retaining moisture and easy application of fertilizers and manures for healthy growth of plants.

Planting distance – Planting distance depends on the type of fruit plants selected. While deciding the planting distance the following points should be remembered.

a) As the tree attains its full growth, the branches should not interlock with the nearby trees.
b) Feeding area for the roots should be taken into consideration to avoid competition with nearby trees.

In addition the following points may also be considered:

a) Type of fruit trees.
b) Rainfall.
c) Soil type ad soil fertility.
d) Rootstocks.
e) Pruning and training

Orchard Cultivation – It involves maintenance of physical condition of the soil, moisture content and its nutrient content. To obtain a good system of orchard cultivation, maximum weeding should be done. Moisture should be conserved and sufficient soil nutrients should be applied. Also, soil erosion should be prevented. One should ensure reduced cost of cultivation.

Soil Management Practices

a) Clean Culture – This involves regular ploughing and removal of weeds. This type of cultivation causes injury to the feeding roots, which result in stunted growth and reduce the trees life. Frequent cultivation also causes soil erosion which result in loss of humus and depletes Nitrogen. These defects in clean cultivation can be minimized by avoiding deep and frequent cultivation.

b) Clean cultures with cover crops – In this type of soil management, green manuring crops are planted between the trees during rainy season and incorporated into the soil at the end

of the rainy season. Crop like French bean, cowpea are most commonly grown as green manuring crops. This also results in extra income to the farmers.

Mulching – Mulching is also very important in soil management. Crop residues like straw, leaves, saw dust and material like polythene films are spread in the inter space of trees. Mulching add humus to the soil and prevent soil erosion. It also conserves moisture and keeps the soil cool in the day, warm at night. Mulching material should not be too dry as it may cause risk of fire. Also thick mulches may act as place for mice and rodents to live and multiply, which may cause damage to the trees.

Intercropping – Intercropping can be practiced in between the fruit trees. The inter crops act as cover crops and benefit the fruit trees through irrigation, manuring given to them. The following points should be considered while growing inter crops.

a) Inter crops should not occupy the area where roots of the fruit trees concentrate.
b) Soil fertility should be maintained or improved when intercrops are grown.
c) Excessive water supply should be avoided.
d) Vegetables are the better intercrops in fruit trees.

Mixed cropping – In this cropping system, perennial crops are grown in between spaces of fruit trees. This helps for utilization of the available area and increase the income of the farm.

Multitier System of Cropping – Some fruit trees take 4-7 years to bear fruits. So, in between the available spaces other fruit plant with lesser root spread (less than 1m in diameter) can be grown.

Organic Farming – To avoid **e**xcessive use of chemical fertilizers and pesticides to boost up our food production which causes considerable damages to our soil health and the environment, organic farming is to be taken up. It is a production system which avoids or largely excludes the use of synthetically compounded inorganic chemicals. This system entirely relies on crop rotation, crop residues, animal manures, legumes, green manures, off-farm organic wastes, biofertilizers, mechanical cultivation etc. and aspects of biological peat control to maintain soil productivity and tilth to supply nutrients and to control insects, weeds and other pests. This system is often, referred as 'biological farming' 'regenerative farming' and 'sustainable farming' 'eco-friendly farming' etc.

Essential features of organic farming

1) Use of organic manures like FYM, compost, vermicompost, coir compost etc.
2) Use of bio-fertilizers.
3) Use of green manures and legumes.
4) Non-chemical weed management.
5) Use of botanicals and bio control agents in the control of crop pests.

Proper Planting

1) Hole slightly less deep than the root mass should be dug.
2) The crown of the plant should be slightly higher than ground level after planting.
3) Bud union should not be planted below the ground.
4) Soil should be amended with organic matter, such as peat, manure, or planting mix.
5) 2-3" deep mulch with bark mulch should be given.
6) All plants should be thoroughly watered when first planted.

7) Deep watering once a week for sandy soils and 10 days for clay soils should be given to thoroughly soak the roots.
8) Water more frequently during first month after installation and during unusually hot, dry periods.

Pruning

Pruning is the process of cutting away dead or overgrown branches or stems to promote healthy plant growth. Improper and untimely pruning does not necessarily kill the plants, but may damage or weaken the plants.

When to Prune

Fruit-bearing plants are best pruned while they are dormant, in late winter through early spring. The primary goal in pruning is to remove old, grey-coloured, slow-growing shoots, which are non-fruitful. (This objective is particularly true of peach trees. Removing 40%of the peach tree annually stimulates new growth each spring). Pruning helps to lower the fruiting zone to a height that makes hand harvesting from the ground possible. Also, it opens the centre of the tree to increase air circulation, reducing disease incidence while still allowing sunlight into the tree to accelerate fruit colouring. Finally, pruning is needed to remove diseased or dead shoot, rootstock suckers and any water shoots.

Pruning and Thinning Tips

1. Aggressive pruning is advised for fruit trees. Done annually, this will maximize fruit production by producing a vigorous plant.
2. The pruning done the first year will determine the shape of the tree in general.
3. After planting a fruit tree should be pruned down to 4-6 ft above the ground.
4. Take out inward pointing branches, branches crossing each other and trim off tips of larger branches.
5. Take off “suckers”. These are shoots coming off the tree below the bud union. Keep doing this annually until the tree is older and suckering slows down.
6. Thin out fruit because if too much fruit is left on the tree, they will be smaller and ripening will be tougher. Try to leave about 8” between fruits the first year, continuing to thin in subsequent years.
7. As the tree matures, continue to trim for shape.
8. For apple, pear, cherry trees a central leader must be left.
9. Peach, nectarine, plum, apricot – make a vase shape, no central leader is needed as all main branches reach up.
10. Always remember that it is difficult to over-prune a fruit tree.

Equipments

The most common equipments/tools are knives, shears and saws. Most of them are designed for cutting stems of up to ½ inch in diameter. Hand pruning shears should not be used to cut larger branches, as this could ruin the shears or damage the plant.

Types of Shears

A hand shears commonly known as secateurs is available in several forms and sizes. Lopping shears are also useful tools, they are used for cutting down branches that are difficult to cut with common hand shears. Pole shears are also useful tools which have a long handle along with a cord or a chain, when the cord is pulled it strike the blades so hard that a clean cut is made without difficulty.

Many types of saws are available in the market. For light work a narrow saw is satisfactory while for surgery, a heavier one should be preferred. Those with curved blade are more convenient.

Equipment Care

Store the tools in a dry room, keep it sharp and maintain its good operating condition by using it on a yearly basis.

When pruning diseased plants, disinfect all shears and saw blades after each cut to prevent spreading disease to healthy plants. Clean and disinfect equipment between each cut when pruning diseased plants with alcohol or bleach by mixing one part bleach to nine parts water. Then oil the pruning equipment well to avoid any rust formation.

Rejuvenating old fruit trees

1. All dead and diseased branches are to be removed. All large cuts should be trimmed till they are smooth on the branches. This will reduce the risk of infecting healthy wood, sterilize the pruning tools with a 1:1 bleach and water solution after cutting away infected wood.
2. Crossing and rubbing branches should be removed and the oldest branches are to be removed first. The centre of the trees should be opened up to allow air to circulate and light to penetrate the centre, allowing for better growth of the fruits and reduction of diseases.
3. Only one-third of the tree height should be reduced at a time over a period of up to 3 years in case of overgrown trees. For e.g. if the tree is 24 feet tall and we want it to be 15 feet tall, 3 feet per year is to be removed.

In the subsequent years, thinning the trees and removing water sprouts that have popped up as a result of the first year's pruning should be continued. Rejuvenating fruits trees takes a lot of effort, but the reward of beautiful harvests for years to come is worth the effort.

First Year

1. Grasses, weeds and bushes growing from around the trunk to the dripline of the fruit tree should be trimmed with a mower or string trimmer to allow more nutrients to enter the root system.
2. All the suckers growing from the roots and around the base of the tree should be removed with hand pruners as suckers divert water from the root system.
3. The main scaffold's limbs are to be trimmed back to a hardy, well-positioned riser or side shoot with the pruning saw. The branches closest to horizontal with ground level are to be removed first. The cuts are to be made with the saw at a 45-degree upward angle to help shield the exposed flesh from precipitation.
4. All hanging, tangled, dead and diseased branches are to be removed from the top one-third of the tree to their branch collars. Make the cuts at 45-degree upward angles.

Second Year

1. The majority of the largest, most vigorous new shoots where they attach to the trunk are to be trimmed back from the top one-third of the tree. Allow a few of the new, healthiest minor shoots that don't offer much shading to remain.
2. The new shoots growing form the top half of the tree should be thinned out, allowing the healthiest, hardiest ones to remain. All new shoots growing from the trunk and scaffold are allowed to remain on the tree.
3. The main limbs are to be spaced evenly around the tree by cutting them back to their branch collars. The weakest limbs are to be removed first, if possible.
4. The limbs are to be shortened above the lower new limbs enough to allow sunlight to reach them, trimming them back approximately 6 to 8 inches.

Third Year

1. The new shoots are to be uniformly cut back from the top one-third of the tree that grew since the prior year's pruning session. Start with the largest, most vigorous shoots first.
2. The fruit tree outer branches are to be reduced by 1 to 2 feet to shape the tree so all areas receive adequate amounts of sunlight and precipitation.
3. New fruiting branches are to be trimmed uniformly, starting at the lower limbs and extending up to highest scaffolds with a spacing of 18 to 24 inches apart vertically around the tree, cutting them back to their branches collars.

25. Orange (Khasi Mandarin) *Citrus reticulate* [Code No. – 51]

Khasi Mandarin is one of the most common citrus fruits grown in the North Eastern region. It is cultivated in almost all states of the North East. There is a worldwide demand of mandarin as fresh fruit. The fruits can be used for the preparation of processed products like marmalade, bottled and canned juices, squash, jam, jelly etc. Orange oil is used for flavouring purposes like hard candy, ice cream, chewing gum and confectionaries. Orange are very nutritious and contain vitamins C, A, B and phosphorous.

Climate – Mandarin prefers sub-tropical climate up to a height of 1500 m above msl. Rainfall of 40 - 45 inches (up to 60 inches) uniformly distributed and temperature of 26° C – 32° C are most favourable for mandarin. Fruit maturation including production of sugars and development of rind colour is best in the lower range of growth temperature. Under heavy rainfall, fruits became poor in keeping quality and inferior in taste. High winds and hailstorm during flowering and fruit set hampers fruit bearing. Flowers and fruits are sensitive to frost conditions and shed within a very short time under low temperature. Low humidity gives good colour and external appearance, whereas, high humidity favours the production of thin layered skin, juicy fruits which are smaller in size but high in quality.

Soils – Mandarin requires light textured sandy loam with deep fertile soils and high in organic matter. The soil should have good drainage and slightly acidic with pH range of 5.5 – 6.5. It requires soil depth of about 180 cm for proper root growth and fruit production.

Cultivars – The following are the orange cultivars.

a. **Coorg** – Fruits are medium to large, bright orange in colour. It is ovate in shape and the base is depressed with thin rind. It matures during February – March. This cultivar is grown in Assam, Meghalaya and North Eastern states.
b. **Khasi** – The fruits are depressed, globose to ovate in shape with orange yellow to orange in colour. It has a smooth surface with an even base or short necked. It is grown in Assam, Meghalaya and North Eastern states.
c. **Nagpur** – The fruits are medium and shape are sub-globose. The surface is smooth with the base slightly drawn out. This is the most popular variety and it matures during Jan- Feb. This is grown in the Satpur Hills of central India, Darjeeling and Coorg.
d. **Kinnow** – The fruits are medium and ovate. The colour is deep orange yellow with a flattened base. The rind is thin and irregular bearing. It matures during mid of January. It is grown in Rajasthan, Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh, Nilgiri, Palni and in the states of Northeast India.

Propagation – The fruit can be raised from seeds and through budding. If Mandarin is to be grown by seeds, then some criteria are to be followed before sowing. They are:-

a. The mother plant selected for seed extraction should be regular bearing with high yield and good fruit quality. It should be healthy and vigour.
b. It should be disease free.
c. Mature and healthy fruits should be selected for seed extraction.
d. The seeds should be treated with *Trichoderma* @ 5-10 g mix with 10-20 ml water for one kilogram of seed. Mix the seeds properly and dry in shade for half an hour before sowing.

The seeds are sown at a depth of 1.5 – 2 cm with the spacing of 10 cm row to row and 5 cm seed to seed. When the seedlings start bearing 4-6 leaves they should be transplanted to poly sleeves of size 8 by 4 inches. The soil media prepared for filling the poly sleeves should be 1:1:1 of sand, soil and well decomposed cow-dung. The transplanted seedlings should be kept in poly-house for quick growth and easy monitoring of pest and diseases.

T- Budding/Shield Budding – This is one of the common way to propagate mandarin, and it gives better performance as compared to the plants raised through seeds. Budding is done during the month of February – March and July –August. T- Budding can be performed in fruit lime or peaches and are called rootstocks. These rootstocks should be healthy, free from diseases and should be one year old. It should be at the height of 1- 1½ feet and thickness of 1 inch. For successful T-Budding the buds should be fully formed, matured and peeled with little damage. The plant being propagated is called scion, while the plant being grafted on is called rootstock. The bud and a small sliver of the wood underneath it are cut from the bud stick selected using an upward slicing motion. The cut should be about ½ - ¾ inches below the bud, and giving another cut across the top of the upward cut. Budding knife should be sharp and less damage should be done to the bud. A vertical cut is made on the stem of the rootstock. Then a perpendicular cut is made at the upper end of the vertical cut forming a shape of 'T'. The bark is carefully slipped from the stem of the rootstock exposing a pocket into which the bud shield can be placed. Care should be taken not to tear the two flaps of bark in the process of spreading them. Then bud shield is then carefully slipped in between the bark flaps. The bud shield should be fitted tightly against the horizontal cut i.e. **T cut**, within the pocket. The bark flaps are held tightly against the bud as they are wrapped with a budding tape. This tape should be removed in 2-3 weeks after the union has healed. After the union has healed the upper part of the rootstock plant can be cut away to force the bud to grow, as this will help the scion to grow vigorously.

Grafting – Grafting is done during the month of July – August. Usually rootstock like Rough Lemon and Rangpur Lime of 90-120 days old is used for grafting. We should select healthy and vigorously growing branch bearing 3-4 buds. This selected branch should be of 3-4 months old and has thickness of 2-4 mm. The leaves of this selected branch should be cut off 7-10 days ahead, before it is used for grafting. The rootstock should be cut away leaving it at a height of 4-6 inches from the soil level and it should bear few leaves before grafting. With a sharp knife, make a one-inch vertical cut through the bark of rootstock stem. Make one inch cuts on both sides of the selected scion and insert it in between the cut rootstock. Now, secure and protect the graft by wrapping it with grafting tape. It takes about 20-25 days for the new buds to appear after grafting.

Air Layering – This method of propagation can be done during the summer season. The followings are the steps to be followed for air layering.

a. Select a branch of about 1-2 years old with one inch in thickness. The branch should be healthy and free from any pest attacks.
b. Two clean cuts should be made around the branch about one inch apart with a sharp knife.
c. Make a soil mixture of moss, sand and wood ash. This soil media can be mix with 500 mg AA or IBA in 1 litre of water before applying to the cut area of the branch.
d. Cover the cut area with the above soil media.
e. With the help of plastic sheet of the right size wrap the soil on the branch.
f. With a cotton thread tie both ends of the plastic tightly to avoid entry of water and air.

g. Wait for 8-10 weeks to allow rooting of the branch.
h. When roots have developed inside the plastic, the branch is cut off below the rooted portion with hack saw with-out damaging the root ball, and is ready to be transplanted.

Preparation of pits and sowing – Before digging pits the soil should be well pulverised and perennial weeds should be removed. Square pit size of 0.75 x 0.75 x 0.75 m (length, width and depth) should be made. Distance from one pit to another should be 5-6 m. Mix the top soil with 20 kg well decomposed FYM together with 500 g *Trichoderma veridae* and filled the pits at least one month ahead of planting.

Time of sowing – Orange seedlings are usually planted during July- August. Irrigation is essential after planting if there is no possibility of immediate rainfall.

Nutrient Management – Manures should be applied when the newly planted seedlings are 4-6 months old. Take 3 kg *Azotobacter* or *Azospirilium* mix well with 100 kg FYM and 3 kg *Phosphatika* and leave the mixture overnight. In the next day the mixture should be applied around the seedlings by giving light ploughing. This manure application should be repeated every 4-6 months. Liquid *Azotobacter* @ 2-3 ml per seedling can also be sprayed.

Water Management – Irrigation improves the plant growth, flowering and fruiting. Lack of irrigation makes the plant look weak and the leaves turn pale. Irrigation should be given lightly after planting of seedlings and should be followed every 15-20 days during the months of December – March.

Mulching – In slopy and hilly areas orange planting should be done by making terraces or half-moon terraces to avoid erosion of the fertile top soils. Mulching with paddy husk or plastics can be done to cover the soil which helps to conserve moisture particularly during winter seasons and suppress weed growth.

Weed Management – Frequent hoeing, hand weeding and light tillage should be done to reduce weed growth and to maintain porosity. Weeding is usually done every two months.

Intercropping – During the pre-bearing stage i.e. within 1-5 years, inter cropping with vegetables like French bean, Soybean, groundnuts can be done. Care should be taken that water does not log around the trunks of the orange plants. Leguminous crops like peas and cucurbits can also be intercropped successfully.

Pruning and Training – Plants should be trained during the first year. All unwanted branches should be pruned leaving only the single trunk about 0.5 m from the soil level. After harvesting of fruits, removal of dead, diseased and over-crowding branches should be done.

Flowering – In Meghalaya orange tree flowers during the months of February – March and fruits ripen during November – December.

Fruit Drop – Fruit drop or flower drop is a physiological disorder in orange plants. The main causes of fruit drop may be due to unfavourable climatic factors, lack of nutrition and improper water management.

Control –

a. Spray multiplex @ 2.5 ml in 1 litre of water.
b. Proper irrigation should be given to the fruit plants.
c. Application of organic manure and nutrients to the plants.

Insect/Pest

1. **Citrus Trunk Borer** – Both the adult and the larvae cause damage to the plant. Neglected orchards are severely affected by trunk borer. The activity of the larvae increase during the rainy season. The pests bore into the stem and branches and cause damage to the fruit plants.

   Control & Management – Pests and larvae should be manually collected and burnt. Multi neem can be sprayed @ 6 tsp in 16 litres of water for three times during April _ July. The holes made by the borers can be cleaned and plugged with cotton dipped in petrol / Kerosene oil. Then the holes are blocked with soil or mud.

2. **Citrus Butterfly** – These pests and larvae mainly infest the orange seedlings in the nursery and the young plants during April –August. The infected plants become weak and bear less fruits.

   Control & Management – Collect the pests and larvae and burn them. Organisms like *Coccinela septempuntata* or *vespa orientalis* could be released to the plants so that they can eat all the larvae of the butterfly. We can also spray garlic paste mixed with 3 ml of neem oil into one litre of water. Spraying *Beauveria bassiana or Bt* @ 1 tsp in 1 litre of water can also be done.

3. **Citrus Psylla** – The adult and the nymphs suck the sap from the plants. The nymphs are more destructive and usually feed on the terminal shoots, buds and tender leaves. The nymphs also inject toxins into the plants and the affected branches dry and die away. The adults are a carrier of viral diseases called Greening which spread from plant to plant. These pests occur mostly during March – October.

   Control & Management – Release *Coccinella septempuntata* or *chrysopid* to the plants as these organisms feed on the nymphs of the pests. Spraying Bio catch *(Verticillium lecanii)* @ 5 ml in 1 litre of water can be done.

4. **Citrus Aphids** – Aphids are of two types i.e. black and green. The black aphids infest the plants throughout the year. While the green aphids can be seen during March – April in the fruit plants. Aphids act as a vector for *Tristeza* virus which causes quick decline. These aphids suck the sap from the growing leaves, shoots and flower buds. This results in shortening of internodes, curling and twisting of leaves.

   Control & Management – All infested leaves and branches should be collected and burnt away. Spray Bio-catch *(Verticillium lecanii)* @ 1 tsp or 5 gram in 1 litre of water during the month of February – March, June – July and September – October.

5. **Mealy bugs** – These bugs usually appear during July – October. They infest both the seedlings in nursery and the full grown plants. The eggs are laid in clusters in a protective cottony mass. They secrete a white sticky coating and suck the saps of tender branches and fruits. Later, the affected parts become pale, wilt and dry up.

   Control & Management – All infested leaves and branches should be collected and burnt away. Digging should be done around the base of the trunk during summer. Then spray *Beauveria bassiana* or Bt @ 5 kg for 2.5 acre of the orchard. During December we can wrap the trunk of the plant with a plastic sheet of about half meter from the ground. Then applying grease all around the plastic sheet will prevent the bugs or ants to climb and infest the plant.

6. **Leaf Miner** – Leaf miners are more prevalent during the months of March- May and July – October, both in nursery and field. The pests are active throughout the year, except severe

winter. Small larvae mine into the leaf tissues making silver coloured tunnels on the lower portion of the leaves. Then the leaves become yellowish and fall off.

Control & Management – Damage parts should be collect and burned. Bio-catch *(Verticillium lecanii)* @ 5 ml per 1 litre of water can be sprayed.

7. **Scale Insects** – These insects feed on tender leaves. They secrete honey dew which attract ants to feed on the dew forming a sooty mould fungus. The infested leaves and fruits die and fall off.

   Control & Management - Damage parts should be collect and burned. Bio-catch *(Verticillium lecanii)* @ 5 ml per 1 litre of water can be sprayed.

8. **Fruit fly** – Fruit fly is usually prevalent during the months of August – September. The infestation by fruits flies causes fruit drop and yield loss. Flies deposit the eggs inside the fruit and the larva drop down in the soil for pupation. Maggots feed on the pulp and the affected fruits fall down.

   Control & Management – Light tillage should be done to the soil at the base of the trunk, to destroy the fallen larvae. After ploughing Pacer *(Metarrhizium anisopliae)* @ 5 kg for 2.5 acre of the land is to be applied.

9. **Bark Eating caterpillar** – This is a serious pest of orange and the infestation of the larva is throughout the year. Eggs are usually laid in cracks on the bark of the plant and after hatching the brown-coloured larva starts feeding on the bark. Larva bores into the trunk of branches and feed inside. In severe cases the plant may die.

   Control & Management – Cotton balls dipped in petrol or kerosene oil are inserted into the holes in the branch and trunk of the plant. Later the holes are blocked by filling with soil and cow-dung mixture.

Overall Management of Insect Pests –

1. Pruning and cleaning of the orchard should be done after harvesting.
2. The trunks of the orange plant should be smeared with Bordeaux paste up to 1 m height.
3. Installation of pheromone traps to manage fruit flies aphids, leaf miner and psylla.
4. The orchard should be monitored frequently.

Diseases of Orange plant

1. **Citrus gummosis** – The pathogen is soil borne and attacks the plant in the basal portion. Large water soaked lesions on the basal portion of the stem is seen. The lesions turn brown and crack. Later, gum comes out of the affected area.

   Control & Management –

   a. The affected parts of the stem should be scraped out properly followed by applying Bordeaux mixture to the trunk about 20-30 feet from the soil level.
   b. The soil should be drenched with *Trichoderma viridae* or *viricon L* @ 1 teaspoonful in 1 litre of water.

2. **Powdery Mildew** – This disease affect the plant both in nursery and field. The powdery growth appears on both sides of the leaf surface. The leaves become small, distorted and fall off causing premature fruit fall. The affected branches may have die back symptom because of secondary infection.

   Control & Management:

   a. Affected plant parts should be removed.

b. Baking soda @ 1 tsp in 3 litres of water can be sprayed.
c. It can be managed by spraying powdery care *(Ampelomyces quisqualis)* @ 1 tsp mix in 1 litre of water.

3. **Scab** – Formation of scabby or corky outgrowth is seen on the leaves, twigs and fruits. The spots are more common on the lower surface of the leaves. The surface of fruits becomes rough and distorted.

   Control & Management:

   a. The infested parts should be removed and destroyed.
   b. Bordeaux mixture @ 1% (100 g lime + 100 g $CuSO_4$ in 1 litre of water) can be sprayed.

4. **Canker and Bark eruption** – The pathogen affect all parts of the plant. Canker-like out growth can be seen on leaves, twigs, thorn and fruits. The lesions appear like water soaked spots which enlarge slightly and turn brown and corky. Severe infection leads to defoliation and die back.

   Control & Management:

   a. Pruning and destruction of infected plant parts
   b. Spraying of Neem oil @ 6-7 tps in 1 litre of water.
   c. Spraying of Bordeaux mixture 1% (100 g of lime + 0.5 litre of water + 100 g of $CuSo_4$ + 0.5 litre of water). This mixture should be sprayed three times during February, October and December.

5. **Greening** – The general symptom of this disease is blotched mottling and yellowing of veins. Leaves fall off during summer followed by twig die back. In severe attack there is reduction in flower and fruit formation. Uneven ripening with one side yellow and other side green is a characteristic symptom on the fruit. This disease is spread by citrus psylla.

   Control & Management:

   a. Proper selection of seedlings before planting.
   b. Removal and uprooting of infected plants and burning.
   c. Spraying of Neem oil @ 6-7 tsp / 1 lit of water.
   d. Spraying of *Beauveria bassiana* or Bt @ 5 g per 1 litre of water

6. **Blue and Green Mould** – The common symptoms is appearance of sooty growth and powdery growth on the fruits usually fruits that have been attacked by fruits flies are more prone to this disease.

   Control & Management:

   a. The infested fruits should be removed and burned.
   b. After harvesting fruits should be stored in a place having proper temperature and humidity.

7. **Fruit Drop in Orange** – Fruit drop usually occurs during the months of May – June. The main causes of fruit drop may be due to climatic changes and improper irrigation. The cause may be also due to lack of manuring or nutrition and plant being infested by pests and diseases.

   Control & Management – Proper irrigation should be maintained specially at the time of fruit bearing period. Proper manuring should be given to the plant. Pruning should be done

after harvesting and there should be no water stagnation at the base of the plant. All the dropped fruits should be collected and buried. Spraying of Multiplex @ 2.5 ml in 1 litre of water can be done.

8. **Citrus Decline** – Citrus decline is one of the main problem in orange plantation which affects the yield badly. Tristeza is a serious viral disease causing various deficiency symptoms in leaves like leaf falling, root decay, die back of shoots and finally death of the tree. Citrus decline may advance in badly maintained orchard, in ill drained soils and also due to malnutrition and insect pest attack.

   Control & Management – Though appropriate control measures are not available as a means of rejuvenating the decline plant, the following measures may be followed.

   a. Removal of all dead woods before new growth starts and spraying Bordeaux mixture and covering all cut surfaces with Bordeaux paste.
   b. Applying more organic manure to the plant.
   c. Regularly following the recommended plant protection for control of pests.
   d. Select seedlings from disease free field.
   e. Use of tolerant rootstock for grafting like Rangpur lime.

9. **Granulation in orange** – Granulation is drying up, becoming hard with greyish colour and enlargement of the juice vesicles. This condition increases the content of pectin, lignin etc. resulting in reduction of the juice content. Granulation occurs more in young Vigorous trees. Factors affecting granulation are:
   a. Climate (Humid).
   b. Cultivars.
   c. Rootstocks.
   d. Mineral nutrition.
   e. Enzyme and plant growth regulator.
   f. Crop load.

   Control & Management – There is no successful method to control granulation in orange. But it can be minimize by spraying Bordeaux mixture 1%. Less irrigation and early picking of fruits can be done.

Harvesting – Mandarin being non-climacteric should be harvested at the right stage of maturity. The tree starts bearing from the 4th year but commercial yields can be obtained from 10th -12th years onwards. Harvesting season starts from August and extends up to April depending upon the location and the variety grown.

26. Pineapple (*Ananas comosus*) [Code No. – 61]

Pineapple originated in Brazil. It is a good source of vitamin A, B, and C. It also contains Calcium, Magnesium, Potassium and Iron. The digestive enzyme Bromalin is also found in pineapple.

Cultivation of pineapple is done in high rainfall humid regions of North East and coastal peninsular India. It can also be grown commercially in areas with medium rainfall supported with irrigation.

1. **Climate -** The pineapple is a crop of humid tropics, the optimum temperature is 22° C to 32° C. It can be grown up to 1,100 m above mean sea level, if the area is frost free.
2. **Soil -** The plants can be grown in any type of soils except very heavy clay soil. Sandy Loam soil is ideal. The pH of the soil should be 5.0 – 6.0.
3. **Varieties:-**
    a. **Giant kew -** It is a late fruiting variety. The leaves are spineless and the fruits are big in size and oblong in shape. Eyes are broad and shallow. It is suitable for canning.
    b. **Queen -** It is an early fruiting variety. Leaves are serrated and eyes are deep - seated. The flesh is sweet and suitable for table purpose.
    c. **Mauritius –** It is a mid-season variety. Leaves are serrated and fruits are medium size, bigger than queen and sweeter than Giant Kew. It is also good for table purpose.
4. **Land preparation:-**
    a. The land should be prepared by clearing of jungle and uprooting of stumps.
    b. In case pineapple is planted on hill slopes, terraces should be made (20-30% slope)
    c. If the land is too sloppy (above 30% slope), terraces should not be made. In these slopes, pineapple is planted in contours to protect soil erosion.
5. **Planting materials:-**

    The planting materials consist of ground suckers, slips and crowns. Crowns take longer and ground suckers and slips take shorter time for fruiting.
6. **Time of Planting** – March – June and August – October.
7. **Spacing –** Plant suckers in double – row system to get more plants per hectare.

    Plant to plant = 30 cm (1 ft)
    Line to line = 60 cm (2 ft)

    Double row to double row = 90 cm (3 ft)

    By this method 43,500 suckers can be planted.

    However, if terrace is narrow, single row can be adopted by planting 25 cm (10 inch) from plant to plant and 75 cm (2 ½ ft from row to row).

    About 44,000 can be planted / ha
8. **Manuring -** 10-15 tonnes of FYM (Farm Yard Manure) can be applied before planting the suckers. Mix the manure nicely with the soil, so that the roots can absorb the nutrient. Application of chemical fertilizer should be avoided.
9. **Interculture –** Weeding and light hoeing should be done in the field to remove weeds which compete with the plants for food, water and sunlight.
    Mulching should be done with straw or leaves to conserve moisture and prevent weed growth. Earthing up of the soil around the plant will prevent lodging of the plants.

Suckers should be removed frequently to avoid over-crowding and this will allow space for intercultural operations.

10. **Inter cropping** – Vegetables, ginger and tuber crops can be grown as rainfed intercrops with pineapple. This will help to obtain additional returns and control weed growth.
11. **Irrigation –P**lants should be irrigated during dry months.
12. **Replanting –** Pineapple should be replanted afresh after 4-5 years.
13. **Diseases of Pineapple** – Root Rot / Heart Rot / Fruit Rot – These are caused by *Phytophthora sp.* and is prevalent in poor drainage conditions.

    Management –

    a. Raised beds are recommended for the cultivation of pine apple with proper drainage system.

    b. Badly affected plants should be destroyed. Spraying and drenching the soil with 1% Bordeaux mixture or *Trichoderma* @ 20 g / 1 lit.

14. **Pest** –
    a. **Mealy Bugs** – This is the most common pest of pineapple. To managed mealy bugs the field should be weed free and ants should be controlled.

    b. **Virus associated Pineapple wilt** – This is transmitted by *Dysmicoccus brevipes.* Preventive measures like destruction of disease plants, keeping the field weed free and control of mealy bugs are to be done.

27. Banana *(Musa spp.)* [Code No. – 02]

Introduction:

Banana is widely grown in India, it is the fourth important food crop in terms of gross value exceeded only by paddy, wheat and milk products and forms an important crop for subsistence farmers. Since it is a rich source of vitamin 'C' and minerals it makes a healthy and salt free diet. In India, it contributes around 31.72% of the total fruit production. India is the largest producer of banana in the world. Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa and West Bengal are the major banana growing states.

Climate and soil:

Banana is a tropical and subtropical fruit crop. It cannot tolerate frost and area of heavy wind should be avoided as it cannot withstand strong winds.

Banana can be grown in all kinds of soils having good drainage. In sandy loam soil plants grow faster than in clayey soil. Area with water logged condition should be avoided.

Important varieties in Meghalaya:

1. Jahajee
2. Malbhog
3. Chini champa
4. Dwarf Cavendish / Green Jahajee
5. Local varieties (Kait khar, Kait shyieng)

Selection of Rhizomes/Suckers – Rhizomes of healthy banana plants should be selected for multiplication. The rhizome are dug and cut into pieces containing of at least one 'eye' or 'bud'. The cut pieces (bits or peepers) are then cleaned and dried in the shade for 4-5 days. They are then planted in the nursery beds at a distance of around 20 cm – 25 cm (8'' – 10") apart.

Preparation of Nursery beds – Land should be ploughed and pulverised to a fine tilt and raised to at least 1(one) ft above the ground. Furrows are made and cow-dung is applied in the furrows. Then the rhizomes which have already been cleaned and dried are placed with the 'eye' or bud' facing upwards at a distance of 8" – 10" apart and covered with soil. They will be ready for transplanting in about 2 months time.

Selection of site – Site should be free from big trees and bamboos. It should get sufficient sunlight and the soil should be rich in humus, deep, loose and well drained. Steep slope should be avoided specially areas with strong winds.

Propagation and planting time – Banana is propagated mainly through suckers. There are two types of suckers:

1. **Sword sucker** – Suckers with a well-developed rhizomes, conical in shape with lanceolate leaves are generally used as they are stronger and healthier that the broad leaves and water suckers.
2. **Broad leaves and water sucker** – Healthy suckers are selected and dug without injuring the rhizomes. They are then cleaned and dried in the shade for 1(one) day and planted in the already dug pits of 2'x2'. With a spacing of 2.5 mts x 2.5 mts or 3x3 mts.

Banana can be planted twice a year that is in the month of May and September – October (15th)

Manuring: Banana is a heavy feeder. So 15-20 kg FYM (Farm Yard Manure) is required for each plant every year for a better yield. In addition:

1. Apply FYM @ 10 kg per plant with 10 gm of *Azospirillum* at the time of planting.
2. Neem cake @ 1 kg per pit can be added into the pit.
3. N.P. and K bio-fertilizer – PGPR mix 1 @ 50-100 gm per pit by mixing with 5 kg FYM.

Management and care – During the first 6 months the plantation should be free of weeds. Old and dried leaves should be removed or cut regularly to help maintain a better growth rate. When fruiting starts, staking should be given to help the plant carry the weight of the fruit less it may break and fall down.

Surplus and unwanted suckers should be kept under control for better growth and yield of the mother plant. De-suckering is required every now and then (45 days). In early stage of plantation emerging small suckers are cut and in the later stages removal of suckers along with the rhizomes to prevent overcrowding is a must.

Intercropping is a common practice in banana plantation to check weed growth, improve soil health and also to augment additional income. Onions, turmeric, ginger, cowpea, beans and yam can be grown as intercrops. Crops like brinjal and cucurbits should not be used because these crops can attract nematodes or soil borne disease.

Pest: Banana stem weevil is a very serious insect pest of banana. The weevil eats the pseudostem causing the plant to tip and fall. It also feed on the rhizomes.

Control: Removing of old rhizomes and cutting of dried leaves helps to keep away the pest. Application of Nisarga (bio-pesticides) around the plant (10 gms Nisarga mix with 2 kg FYM) helps to control the banana weevil.

Diseases: Bunchy Top is the most significant disease in banana. The top of banana is bunched up and growth is stunted. Affected plants should be cut and burn down.

To avoid the occurrence of this disease every five years new plantation should be started.

28. Strawberry *(Fragaria ananassa)* [Code No. – 71]

Strawberry is considered as a complete fruit with 98% edible portion. The fruit is rich in vitamins C and B, proteins and minerals like P, K, Ca, Fe. Strawberries are best source of antioxidant and it is also anti-carcinogenic and anti-diabetic. It has low calories, no cholesterol and high level of minerals.

Varieties – Strawberry varieties are Camarosa, Ofra, Sweet Charlie, Chandler, Elisa, Fair Fox, Searcape, Blakemore, Douglas, Fertility. Strawberry is the only crop in which all cultivars have been developed by hybridization.

Site selection – There should be transportation facilities and nearby market. It requires adequate labour availability. It also need appropriate climate and supply of good quality water.

Soil – Strawberry plant grows best in sandy loam soil. Very light soil is needed with frequent irrigation for the establishment of runners. It prefers soil rich in humus as 70% - 90% of its roots were found in the top 15 cm soil. It grows best in slightly acidic soil of pH 5.5 – 6.5.

Climate – Strawberry plants are strongly affected by environment parameters like temperature, photo period and light intensity. It requires optimum day temperature of 22° - 25° C and night temperature of 7°C - 13° C. Frost and winter injury seriously reduce the yield of Strawberry. Frost injury may be reduced using mulch, covering rows with plastic and by creating good air drainage. Photo period has a marked effect on strawberry vegetative growth, plant morphology and yield. Stolen formation, petiole length, leaf area and yield increases with the increases in photo period.

Propagation – Propagation is done through seeds, vegetative means as well as through Tissue Culture. Propagation through seed is not advisable because they do not produce true to type plant. Seeds also require stratification to break their dormancy. Strawberry is mainly planted through vegetative propagation.

Runner production – Viral disease are often transmitted through runners. A separated bed should be used for runner production. The site or soil where the strawberry had not been grown for at least 3-4 years should be selected. The planting should be done at 1.2 x 1.2 m or 1.8 x 1.8 m distance. For greater survival and fast growth, the runners should be lifted in September and planted in poly sleeves using potting media of 1 soil: 1 sand : 2FYM for one month. In this method mortality in the field is less and growth picks up within 3-4 days after transplanting.

Cold storage of runners – Runners can be kept in cold storage for planting during spring. Runners are lifted in late November – December and should be packed in bundle of 200-250 in polythene bags, not more than 0.07 mm thickness and stored until June – July. Runners can be kept in good condition for 3 months at 0 or -1° C. It should be removed from cold storage during April – May and planted as soon as possible to avoid injury from heat.

Land preparation – FYM should be applied on the top soil. Healthy runners with medium to large crown and well- developed root system are planted in the field. The outer leaves should be stripped off and the roots of the runner should be washed before planting.

Time of Planting – In Meghalaya strawberry is planted during 15th September to 15th October.

System of planting & spacing – Strawberries can be grown in different methods like matted rows, spaced beds, hill rows, in containers, under plastic, low tunnels and protected cultivation. In hill row system, plants are grown either in single or double row on 15 – 20 cm raised beds. Runners are set 20-25 cm apart in twin rows 30-35 cm apart and distance of 90-120 cm is kept between twin rows. Low tunnels with flexible transparent plastic covering (UV stabilized plastic (50-100) micron) are installed over rows of individual bed to enhance plant growth by increasing the air temperature around the plants during winter. Row cover is an effective technology in hill row system of planting. Galvanized iron arches are fixed 1.5 – 2.0 m apart, width of two loops are kept 60-90 cm with a same height of 60-90 cm above the level of beds. Three parallel wires, one at centre and one each in both sides should be spread for covering plastic and making tunnels over plants. After transplanting, plastic is covered on beds manually. Small vents are made on eastern side of tunnels at 2 m spacing for proper ventilation in tunnels.

Irrigation – After transplanting irrigation is essential for rooting of runners. Drip irrigation is used so as to avoid excessive watering of the seedlings. Excess irrigation increases the incidence of Botrytis rot and discourages the growth of leaves and stolon.

Nutrient Management - Application of 20 tonnes of FYM / ha should be done before planting of seedlings. After 2 months of planting the soil should be inoculated with *Azobacter* + *Azospirullium* @ 2 kg / ha by mixing with 50 kg of well dried FYM. Bone meal and wood ash may be added to supply P&K to the plants. Bio-fertilizer and Nitrogen levels influenced the plant nutrient content. This maximises growth in terms of plant height, number of leaves, leaf area, crown and total biomass.

Mulching – Mulching minimizes the freezing injury, suppresses weed growth and reduces soil erosion. Clean white straw, marsh hay, pea vines and saw dust can be used as mulching materials.

Cultural Practices - Removal of 1-2 buds improves fruit yields and quality, however excessive bud removal reduces production of numbers of fruits and reduces yield. De-blooming is done to remove the flower truss to prevent plant fruiting specially in runner beds. Removal of blossoms from mother plants increases the production of early runners. The runners should be allowed to root along the rows until sufficient crowns are formed and excess runners should be removed from the rows.

Harvesting – Berries are harvested when 50-75% skin of the berry develops colours. Fruit are picked with cap and stem of 12 mm length. During peak period, berries should be picked daily or in alternate days. Fruits are harvested in shallow trays as it is highly perishable and easily get damaged if bulky containers are used.

Handling – As the fruit is highly perishable the storage of berries for even a short period is not recommended. During transportation it ripens very fast and gets spoiled easily. Therefore careful handling, cooling and packing should be followed. Strawberries are packed in plastic punnets and are placed in corrugated fibre trays or ventilated cardboard boxes. Wrapping the strawberries with semi permeable film after harvest minimizes weight loss of fruit.

Uses of Strawberries – It is used as fresh fruits. Mostly strawberries are processed as jams, ice-cream, crushed strawberries, strawberry syrup and strawberry wine.

Insect Pest & management in Strawberry crop

Pest like Aphids, leaf roller, spotted red spider mite and Nematodes frequently damage the strawberry crops. These pests can be managed by practicing clean cultivation. Two sprays of Neembicidine or Neem Oil spray @ 10 ml / 1 lit water or *Bacillus thuringiensis* @ 5 g / 1 lit of water for control of leaf folder and aphids can be done. Coloured traps can be installed in the field to trap the population of aphids and other pests. Use of healthy runners and avoiding infested soil for planting followed by crop rotation with resistant varieties can control nematodes and other pests.

Diseases & Management

Strawberry crop is mostly infected by leaf spot, grey mould or fruit rot, verticillium wilt and virus diseases. Spraying with *Trichoderma* and *Pseudomonas* @ 5g/1 lit of water can control the above diseases. In addition we should use disease- free planting materials. Infected plant debris should be removed and burned. Over all good sanitation in and around the field should be maintained.

29. Jack fruit *(Artocarpus heterophyllus)* [Code No. – 36]

Jack fruit grows best in humid regions with tropical climate. In Meghalaya it grows well in the Southern Hills slopes bordering Bangladesh. Ripe jack fruit is eaten as fruits but unripe fruit is prepared as vegetable. Jack fruit flesh is very sweet and aromatic. Jack fruit has many health benefits as it contains calcium, carbohydrate, vitamin A, fibre, protein etc.

Jack fruit varieties are classified according to the texture of the flesh. Hard jack fruits are bigger in size with firm flesh. On the other hand, soft jack fruit are smaller but sweeter and softer in consistency.

Planting Materials- Jack fruit is usually propagated through grafting. Grafted seedlings free from pests and disease infestations are used as planting materials. One-year old grafted seedlings should be planted at the onset of monsoon.

Planting – Pit size of 60cm x 60cm x 60cm should be prepared at a spacing of 12-15 m. The pits should be filled with a mixture of top soils and 10 kg well decomposed FYM. Deep planting should be avoided as it results in poor growth of the graft. It should be ensured that the graft joint is above the soil level. The seedlings should not be exposed to draught and frost. Adequate drainage and watering results in better performance of the seedlings.

Harvesting – The plant generally bear fruits after 8 years and grafted plants bears after three years of planting. Harvesting is done during May-June.

Plant Protection – The pest of Jack fruit are shoot borers, caterpillar, mealy bug and jack scale. Two sprays of Neembicidine or Neem Oil spray @ 10 ml / 1 lit water or *Bacillus thuringiensis* @ 5 g / 1 lit of water for control of the above. The common diseases are pink disease, stem rot and fruit rot plants. Pruning of the affected plants and protecting the cut ends with Bordeaux paste can manage the above diseases. Also spraying of *Trichoderma* and *Pseudomonas* @ 5g/1 lit of water can control the above diseases.

Important Facts of Jackfruit

1. Jackfruit is recognized as the largest tree fruit, growing as big as 36 inches long and 18 inches wide, and weighing as much as 22.67 kg.
2. In single year, the jackfruit tree can produce as many as two hundred fifty fruits.
3. Jackfruit varieties are classified according to the texture of the flesh. "Hard" jackfruits are those that are bigger sized and have firm flesh. "Soft" jackfruits on the other hand, are smaller but sweeter and softer in consistency.
4. The number of seed that can be found in a jackfruit range from 100 to 500.
5. The jackfruit's flesh is very sweet and aromatic, having been described as having the flavour combination of mango, banana, melon and papaya.
6. Ripe jackfruit is eaten as fruit but unripe fruit is eaten as vegetable.
7. Other processed products can also be made from jackfruit.

Health Benefits of Jackfruit

1. Maintains healthy thyroid.
2. Strengthens bone.
3. Lowers blood pressure.

4. Jackfruit seeds contain Vitamin A that is an essential vitamin for healthy hair and to prevent dryness and brittleness of hair.
5. Jackfruit seeds can aid in healthy blood circulation that is vital for good hair growth
6. Jackfruit is loaded with carbohydrate and calorie. It gives instant energy.
7. Maintains healthy eyes and skin.
8. Jackfruit is a rich source of dietary fiber that make it a bulk laxative. This helps to improve digestion and prevents constipation.
9. Prevents cancer.
10. Jackfruit also contains calcium which strengthen and promotes healthy bones. Aids in preventing osteoporosis.
11. Contains a good amount of vitamin-A and can prevent night blindness.
12. An extract from leaves and latex cures asthma, prevents ringworm infestation and heals cracking of feet.

Nutrition

One cup of raw, sliced jackfruit contains about:

1. 155 calories
2. 2.6 g Fibre
3. 2.4 g Protein
4. 39.6 g Carbohydrates
5. 0.5 g Fat

It is high in calories, very high in water (roughly 80%) and is extremely low in fat.

Value Added Products of Jackfruit

Jackfruit often considered as a 'wonder' fruit, is eaten as a vegetable when tender. For vegetarians, it serves as a meat substitute. Ripe jackfruit bulbs (flakes) are consumed worldwide as a dessert fruit. The pulp is also used to flavour ice cream and beverages and preparing drinks. The mature fruit can be used to prepare chips and papad. When ripen, it can be used to prepare squash, jam and jelly. The seeds can be eaten boiled, roasted or dried and served as table nuts, or they can be grinded to make flour and blended with wheat flour.

List of Food Products Made From Jackfruit:

1. Jams
2. Juices, squash, Ready To Serve (RTS), syrup
3. Canned segments
4. Drum-dried powder
5. Flour
6. Jackfruit chips
7. Dehydrated jackfruit seeds
8. Jackfruit cake

Other Uses of Jackfruit

1. Jackfruit paste in applied to the skin for poisonous bites
2. The wood derived from the jackfruit tree is highly prized because of its termite and fungus-resistant properties. It is used in making furnitures, houses, musical instruments, bee hives, oars etc.
3. A yellow dye also can be extracted from the wood particles and used as dye.
4. The rind of the fruit and leaves can be used as fodder.

30. Kiwi (*Actinidia deliciosa*) [Code No. – 39]

Kiwi fruit is rusty brown with hairy surface and oblong in shape. The flesh in cross-section is light green in colour and seeds are soft and small. The fruit is delicate and flavour like Strawberry and Gooseberry. The fruit is highly nutritious and rich in minerals, sugar, vitamins and carbohydrate.

Climate

Kiwi fruit grows at altitudes between 600-2000 mm. Kiwi fruit can withstand a temperate of about 12°C when fully dormant. However, they must acclimate to cold slowly and any sudden decrease in temperature may cause trunk splitting and subsequent damage to the vine.

Soil

Kiwi fruit prefers deep and well drained sandy loam to clay loam soils that are rich in organic a matter. Although it grows in soil with pH between 6.0 and 8.0 they do best in a neutral pH of about 7.0.

Seedling are planted at a spacing of 6x6 m in the month of Dec-Jan and frequent light irrigation is required after the planting.

Propagation

Since kiwifruit is a dioecious plant, it can be propagated only through vegetative means. Commonly hardwood cuttings of winter pruning are used for propagation. Three node cuttings are take for the commercial production of seedling. Seedlings from the seed can be used for the rootstock in grafting.

Cultural practices

Kiwifruit vines require a great deal of water. In hot summer weather, the vines large leaves transpire water rapidly. In summer, newly planted vines in average soils should be watered deeply about once a week. Overhead sprinklers are often used in commercial kiwifruit vineyards for frost protection as well as irrigation (sprinkler heads should be about 3 feet above the training wire). One dose of manure and fertilizers should be applied just after fruit harvesting and other at the time of fruit setting i.e. April-May.

Pruning

Two pruning are essential for the maintenance of the kiwifruit orchard. Winter Pruning in the month of Dec- Jan at 5-6 node stage is most essential for the regulation of the flowering and another pruning in the month of July is essential to maintain proper vegetative growth of the orchard.

Training

The T- Bar usually consists of an 8-10 ft wooden post (4/4 inch minimum thickness and pressure treated with preservatives), firmly set (at least 2-1/2 feet deep) in the ground or concrete, with a 6 foot long, 2/4 inch cross bar about 6 feet from the ground.

A third wooden piece is often added as a brace between T-bars, which are spaced 15 feet apart. Pulled, 8-10 gauge galvanized wires are strung between T-bar and are pulled taut. Attach the wires to a very sturdy end post or anchor them firmly to the ground or a building. Place T-bars no closer than 2 feet frim the vines. The centre ire will support the main cordons, and the outer wires will support the fruiting laterals as described below. The following illustrations show a kiwifruit vine being trained to a T-bar trellis.

Pollination

Kiwifruit plants are normally dioecious, meaning that individual plant are male or female. Only female plants bear fruit, and only when pollenized by a male plant. One male pollenizer is required to be planted for each six to eight female vines.

Harvesting and storage

Mostly fruits ripe in the last week of October to the first week of November. Fruits can be stored up to three months at room temperature due to hairy fruit surface and less evaporation.

Insect

Compared to other fruits type, kiwi has few insect pests. European red mite can build up in late summer in hot, dry areas. Scale insects and leaf rollers are other pests affecting it.

Management & Control

i. Hand picking of the caterpillar
ii. Damage parts should be collect and burned can be sprayed.
iii. Spraying with Bio-catch (*Verticillium lecanii*) or *Bacillus thuringiensis var* @ 5 ml per 1 litre of water.
iv. Spraying with Neembicidine @ 6 – 7 tsp per 16 lits of water.

Varieties

Female

Allison, Brono, Monty, Hayward and Abbott.

Male

Matua and Tomuri

Advantageous properties of Kiwifruit

1. It contains high vitamin C levels, evidently exceeding those of any citrus fruit.
2. It has a enzyme that has meat tenderizer type properties.
3. It can survive for long periods after picking. After reaching full size, the fruit can take as long as two months to ripen but this can be speeded up by exposing them to ethylene gas which in a household situation can be achieved by keeping them enclosed with bananas or apples. They can be kept 4-6 months in cold storage. These long storage periods are particularly favourable to hill growers because they are so far from the main markets.

31. IPM in Fruit Crops [Code No. – 35]

Citrus

Insect Pest

1. **Citrus trunk borer**
    a. Pruning and burning of the dried and withered branches, kills the overwintering stages of sucking pest and larvae / pupae of trunk borer and shoot borer.
    b. Collection and destruction of adult during April to August, by shaking the trees results in satisfactory control of trunk borer.
    c. Injecting 5ml of kerosene or petrol per hole by syringe and sealing with mud kills larvae of trunk borer.

2. **Orange shoot borer**
    a. Pruning and burning of the dried and withered branches, kills the overwintering stages of sucking pest and larvae / pupae of shoot borer.
    b. Insert into the borer holes with cotton soaked in kerosene / petrol and plastered on the outside with mud kills larvae of orange shoot borer.

3. **Bark eating caterpillar**
    a. During February-March, insert into the borer holes with cotton soaked in kerosene / petrol and plastered on the outside with mud.
    b. Remove and destroy the affected twigs.

4. **Citrus caterpillar**
    a. Hand picking of the caterpillar.
    b. Application of *Bacillus thuringiensis var .kurstaki* @ 1 kg / ha or neem seed kernel extract (3%).
    c. Spaying with *Beauveria bassiana* @ 5g / 1 of water.

5. **Citrus leaf miner**
    a. Hand picking of the caterpillar
    b. Application of *Bacillus thuringiensis var .kurstaki* @ 1 kg / ha or neem seed kernel extract (3%).
6. **Citrus psylla**
    a. Release of predatory coccinelids like *Coccinella septumpunctata*
    b. Spaying with *Verticilium leccanii* @ 5g / 1 of water.

Diseases:

a. Damping off: spraying and drenching with *Trichoderma harzianum* @ 5g / liter of water
b. Powdery mildew: Spraying of sulfex @2.5 g / litre of water
c. Scab: Spay Bordeaux mixture (1%) during the month of February, October and December.
d. Canker and bark eruption:: Spay Bordeaux mixture (1%) during the month of February, October and December.

Temperate fruits

Insect Pest

1. Peach stem borer
   Host: Peach, plum
    a. Removal of dead or heavily gummed branches.
    b. Tying of a 1 cm layer of dry grass or a layer of gunny burlap on the exposed stem and branches from Feb-Nov.

2. Peach twig borer
   Host: Peach, plum
   a. Remove and destroy all affected shoots and fruits.
3. Peach leaf curl aphid
   Host: Plum, Peach
   a. Removal of weeds.
   b. Release of predatory coccinelids like *Coccinella septumpunctata.*

4. Peach fruit fly
   Host: Peach, Plum
   a. Hoe the orchard in May and June to expose the pupae which are present in the soil
   b. Raking of the soil and application of *Metarrhizium anisopliae.*
   c. Collect and destroy the fallen fruits.
   d. Use of para pheromone trap like methyl eugenol @ of 3-5 traps / acre.

Diseases:

   a. Powdery mildew (Peach): Spraying of sulfex @2.5 g / litre of water.
   b. Shot hole (Peach): Spray Bordeaux mixture (1%).
   c. Bacterial gummosis (Plum): Clean the wound and apply Bordeaux paste to the infected area, soil application by drenching *Trichoderma viridae* @ 5g / litre.
   d. Fireblight (Pear): Spray Bordeaux mixture (1%).

32. Oyster Mushroom *(Pleurotus florida)* [Code No. – 55]

North East India has a very good prospect for cultivation of mushroom because of the prevailing and favourable weather condition for its production. Mushrooms are called 'white vegetables' or boneless 'vegetarian meat'. It contains protein, vitamins and fibre apart from having medicinal properties. Among Oyster mushroom *P. sajor – caju* and *P. florida* are commercial species suitable for round the year cultivation. Its cultivation requires minimum investment but has maximum profit potential in the market. The used straw after harvesting is nutritious and can be incorporated into the soil for enriching it. Oyster can be grown in temperature of 20-30° C.

Sowing time – March – October.

Cultivation of Oyster in Polythene bags.

Requirements for cultivation

1. Clean Paddy straw
2. Transparent polythene bags of size 1.5 ' by 2 feet
3. Spawn
4. Dark room to induce germination
5. Well ventilated rooms
6. Drums
7. Sprayer
8. Firewood
9. Bamboo / cane baskets
10. Chaff cutter / Dao
11. Watering can

Preparation of growing media

1. Clean paddy straw is chopped about 15 cm with the help of a chaff cutter or dao.
2. Soak the cut straw in a water drum for 6-8 hours.
3. Drain off the water and boil the straw in hot water for at least 30 minutes so as to disinfest the straw.
4. Drain off the excess water and allow it to cool in shade. Spray garlic solution @ 6 tsp in 1 litre of water to avoid any diseases.
5. Make about 20 holes in the poly bags at a distance of 10 cm.

Planting of Oyster Seeds

Seed requirement – 300 gms of seed is required for 1 kg of paddy straw. Whereas 100 gms of seed is required for planting 1 polythene bag.

1. Take 100 gms of Oyster seed and divide it into four equal parts in a clean tray.
2. Fill 6 cm of perforated poly bag with the straw and press it slightly. Then sprinkle one part of the above seeds uniformly over the straw. Cover again the seeds with straw for another 6 cm thickness.
3. Repeat the process 4-5 times in such a way that the level of straw should be 5 times and the level of seeds should be 4 times in one polybags. Then tie the mouth of the bag.

4. Place the filled polybags in a shelf in the dark room. The room temperature should be maintained at 25°C. Leave the bags for at least 12-20 days in the dark room. After 14 days white threads like growth will be seen covering the straw fully.
5. Remove the polythene bag cover carefully when the pin heads start emerging.
6. Keep these straws in a well-ventilated room. Allow partial light to enter the room. However temperature should be maintained at about 23°C. If temperature rises, the floor of the room needs to be sprayed with water to retain humidity of 75 – 90%.

The following points should be remembered after planting of Oyster seeds.

1. Watering is not required until pin head formation is seen. Watering should be done 2 days after the removal of the plastic bags.
2. Watering can should be used to sprinkle water to the fruiting bodies i.e. in the morning and evening.
3. Within 5-7 days the first flush of fruiting bodies appears which can be harvested.
4. Subsequent flushes appear about every 10 days and 2-3 harvesting can be done.
5. Keep the surrounding areas neat and clean. Put mosquito net on the ventilation to check flies.

Diseases and Management

The main disease of Oyster mushroom is fungus. After 7-8 days of planting of seeds, a fungal like greenish substance may be seen in the straws. The main causes of this moss formation might be due to seed borne disease or the paddy straw used as media was not properly boiled.

Control

1. Spraying 6-7 tsp of garlic solution mix with 1 litre of water to the paddy straw before planting of seeds.
2. Select clean and disease free seeds.
3. Sanitation and hygiene are important measures to prevent pest and diseases.
4. Avoid using damaged and old straw as planting medium.
5. Remove and destroy the infected blocks immediately.
6. Avoid preparing block with more than 70% moisture.
7. Polythene bags should be properly washed and dried before re-use.
8. Water stagnation should be avoided on the floor to prevent insect/flies and to prevent unwanted growth of moulds.

Control of Pests on Oyster

1. Spraying Bleaching powder @ 2 g/ 10 litre of water all around the floor of the room.
2. Spraying Neemagon/Neemgol/Rakshak @ 3 ml mix in 1 litre of water to the paddy straw before sowing of seeds.
3. Covering the ventilation outlets with the help of mosquito nets.
4. Using fluorescent strip traps in the growing room.

Harvesting

In about 3-4 days, the first flush of fruiting bodies appears which can be harvested. The matured Oysters are harvested along with the roots. The harvested mushroom should be stored in brown paper bags or in perforated plastic bags for marketing.

Storage:

Being highly perishable, oyster mushroom should not be stored for a long time. However the followings should be followed for storage:

1. Dry the harvested oyster mushroom in shades for about 2-3 days.
2. Store the harvested mushroom in refrigerator and it may last for 7-15 days.
3. Keep the harvested mushroom in saline water by mixing 10-15 gram salt in 100 ml of water. Mushroom can be kept for 6-7 days in the saline water.
4. Mushroom can be processed by canning them.
5. It can be processed for pickles, nuggets, soup powder etc.
6. It can be processed for medicinal purposes.

33. Processing of Fruit and Vegetables [Code No. – 65]

EQUIPMENTS - The following equipments are required for preparation of fruits & vegetables products.
Stainless steel pan, stove, weight box & balance, Juice extractor wooden ladle, pineapple puncher (Stainless stell glass may also be used Refractometer & Thermometer).

A. SQUASH: JAM

EXTRATION OF FRUIT JUICES/PULPS
Select fully ripe or matured fruits free from diseases and insect damages for processing.

1. **ORANGE:** Peel the oranges and immediately extract the juice with the help of juice extractor and simultaneously add 50gms/10 table spoonful approximately, from the require quantity of sugar to prevent bitter of the juice.
2. **PINEAPPLE:** Peel the selected pineapple with the help of a stainless steel knife and cut into small pieces, crush the pieces with the pineapple puncher or with a stainless steel glass, if puncher is not available. Put the crusher pineapple pieces in a muslin cloth and squeeze out the juice, then filter the juice again in a muslin cloth.
3. **SOH PYRSHONG (CARAMBOLA):** Wash the fruit thoroughly and extract the juice with the help of juice extractor.
4. **SOHBRAP (PASSION FRUIT):** Wash the fruits and cut them into halves with the help of a stainless steel knife and extract the pulp from the cut fruits with a spoon. Extract the juice by passing the pulp through a net cloth.
5. **SOHIONG (PRUNUS NEPALENSIS):** Clean and wash the fruits properly and boil in water till the fruits become soft. Extract the pulp by crushing the boil fruit in a bamboo sieve.

Preparation of Syrup

Dissolve the required quantity of sugar separately in water as per recipe on a slow fire with continuous stirring and heat up to boiling point. Then add whole quantity of Citric where ever is necessary in the sugar syrup. Filter the prepared syrup and let it cool down to room temperature.

Recipe for 4 litres (approx.) Squash

Sl. No.	Type of Squash	Juice (lit)	Water (lit)	Sugar (kg)	Citric Acid (gms)	Potassium Metabisulphide (gms)	Essence	Colour (Drops)	Sodium Benzoate (gms)
1.	Orange	1.000	1.500	1.500	50	2.9	1 or 2 drops	1 pinch	-
2.	Pineapple	1.000	1.500	1.500	40	2.9	1 or 2 drops	-	-
3.	Sohpyrshong (Carambola)	1.000	1.285	1.680	30	2.9	-	-	-
4.	Sohbrap (passion fruit)	1.000	1.410	1.650	30	2.9	-	-	-
5.	Sohiong	1.000	1.400	1.560	30	-	1 or 2 drops (Strawberry Essence)	-	2

1. SQUASH

Mixed the juice with Syrup and add the whole quantity of Potassium Meta Bi-Sulphide by first dissolving it in a spoon of water or sodium benzoate in case of Sohiong preparations, one or two drops of essence and a pinch of colour where ever is necessary, fill the prepared squashes in clean sterilized bottles, seal properly and store in a cool dark place.

2. JAM

Jam may be prepared from a single fruit or combination of two or more fruits, dried, canned fruits or preserved pulps may also be used.

EXTRACTION OF PULPS- Fruits may be crushed or cut into small pieces with the help of stainless steel knife and boil with a sufficient quantity of water, then passed the boiled fruits through a fine sieve to obtain the pulp.

RECIPE:

1 Kg pulp
1 Kg sugar
5 gms ready made fruit pectin
2 gms citric acid (Citric acid is not necessary in case of Plum & Sohiong jam)

Colour may be used in case of mixed fruit jam. Sprinkle the required quantity of Pectin mixed with small quantity of sugar to the pulp and boiled for 5 minutes then add equal quantity of sugar to the pulp (i.e., 1 kg pulp & 1 kg Sugar) and heat the content stir well with wooden ladle till heavy consistency and add citric acid. When the total soluble solids reached 68.5° Brix as determined by "Refractometer" then stop boiling, fill the prepared jam in clean and sterilized jars and seal properly. If the jam is to be packed in cans it should be filled while it is still hot, seal, invert the cans and pasteurized for about 30 minutes at 82° C to 85° C and cool in water. In case of larger size cans, i.e., above A-2 ½ cans pasteurization is not necessary.

C. PICKLES

Pickles maybe prepared from a single unripe fruits or vegetables or a mixture of both according to one likes.

Curing of fruits /vegetables: Dissolve 360 gms common salt in 1640 ml of water (18% salt solution) and filter in muslin cloth, then add 2 gms sodium benzoate and 5 gms turmeric powder and stir well. Place 1 kg of the cut fruits / vegetables in suitable containers having lids, fill in with the above prepared solution, close the containers properly and allow to cure for a minimum period of 2 (two) week's time.

RECIPE:

1. 1 Kg fruit / vegetables
2. 10 gms sarso
3. 10 gms dhania
4. 10 gms methi
5. 10 gms kala jeera
6. 10 gms sauff
7. 10 gms ajwain
8. 30 grns chilli powder
9. 750 ml mustard oil.

After curing period is over, drain off the solution properly from the fruits / vegetables and mix with the already roasted and ground spices, then place the fruits / vegetables in sterilized bottles and fill in with pre-cooked & cooled mustard oil and seal properly.

TOMATO KETCHUP

Select deep red well matured tomatoes, free from blemishes and insect damage.

Recipe

Tomatoes	6 kgs	Cinnamon (Dalchini)	5 gms
Onion	100 gms	Cunin (Jeera)	2 gms
Garlic	5 gms	(Salt to taste)	
Cloves (long)	2 gms	Red Chille Powder	5 gms
Cardamon (Elaichi)	2 gms	Acctic acid	10 ml
Black Pepper	1 gms	Sodium Benzoate	1 gm

Preparation: -

Cut the tomatoes into small pieces and boil in an aluminium pan till they become soft, then pass the boiled tomatoes through a fine bamboo sieve to obtain a clear pulp free from skin and seeds. Boil the pulp again along with the required quantity of sugar and dip ground spices tied in a muslin cloth while boiling and remove when the ketch up is ready and add salt towards the end of boding.

When the ketchup is ready add the required quantity of Acetic acid and stir properly followed by Sodium Benzoate, stir and keep in air tight containers.

34. Azolla (*Azolla pinnata)* [Code No. – 92]

Azolla is a fresh free floating water fern. It is one of the fastest growing plants due to its symbiotic relationship with Blue Green Algae (BGA) which is responsible for nitrogen fixation in the rice crop. It is being used as common bio-fertilizer and green manure in rice fields in the North-eastern region. Depending on species it is grown easily in ponds, ditches and rice fields in warm areas. Azolla is also an excellent alternative feed supplement to live stock, poultry and fish.

Nutrient Content of Azolla – Azolla has many nutritional benefits when compared to other fodders. It contains the following nutrients.

Nitrogen	-	5.0%
Phosphorous	-	0.5%
Potassium	-	2.0 - 4.5 %
Calcium	-	0.1 – 1.0 %
Magnesium	-	0.65 %
Manganese	-	0.16 %
Iron	-	0.26%
Crude fat	-	0.3 – 3.3%
Sugar	-	3.4 – 3.5 %
Starch	-	6.5%
Chlorophyll	-	0.34 – 0.55 %
Ash	-	10.0 %

Azolla caroliniana is a variety which can thrive well in cold regions even when the temperature goes down during winter. In Meghalaya this Azolla can be grown from December to February. Besides other varieties, *Azolla pinneta L.* is cultivated abundantly in the other states of North East India. Azolla innoculums can be preserved in a pond of 3 m x 2 m x 1 m with 15 cm water level, over-head shade with grass or paddy straw is to be provided. It can be multiplied easily through any broken part of the plant, preferably during April. Azolla can produce 8 – 10 t/ha of green biomass in 20 days.

How to grow Azolla

1. Azolla can be grown abundantly in dugout ponds that can hold water, concrete tank, rice field. The dug out pond should be of size 3x2x1 m and the water level should be maintained at 10 cm – 15 cm depth.
2. Azolla like any other plants needs nutrients, therefore addition of FYM in the dugout pond is recommended.
3. 50-200 grams of Azolla mix with ash bone and *Azospirillum* is to be added into the prepared pond.
4. Azolla is a highly productive plant and it doubles its biomass in 4-10 days and multiply to form a carpet on the water surface. This can be harvested and use immediately or dried and preserved for later use. This process can be repeated to produce more Azolla culture. Azolla should be removed daily to prevent overcrowding.

The green Azolla harvested can be applied into the field prior to paddy cultivation. It can also be grown in the same field before transplanting. Azolla when incorporated into the soil, decomposes rapidly within 7-10 days. Thus nitrogen availability extends from 1-10 weeks in paddy field. Harvested Azolla can be stored in pits and covered well for later uses. It takes one month for Azolla to decompose in the pit. This decomposed Azolla can be applied as manure for crop cultivation.

Green Azolla can be harvested within 15 – 20 days during summer and 25-30 days during winter after inoculation into the pond. One third of Azolla should be left in the pond for further multiplication.

Field Application:

1. Incorporate as green manure before transplanting of rice (500 kg / ha).
2. Dual culture with rice 7 days after transplanting and allow to multiply.

Optimum conditions for growing Azolla in the hill areas:

1. **Water** – The water level in the pond where Azolla is raised should be maintained at 10 – 15 cm.
2. **Temperature** – For growing Azolla, the optimum temperature during the day time should be 32°C and 20°C during the night, although some species can grow at low temperature.
3. **Light** – Light affects photosynthesis and regulates nitrogenase activity in Azolla. However as Azolla grows best in less sunlight, it thrives best in paddy fields as it obtains shade from the crop.
4. **Medium** – Azolla can grow well in acidic medium of pH range of 5.2 – 5.8.
5. **Minerals** – Azolla requires essential elements for its rapid growth. Although it does not require nitrogen in its growing medium, the level of nitrogen affects its growth. Therefore, at the beginning of the cultivation, cowdung, bone meal, rock phosphate wood ash can be added to soil as nutrient supplements. The contents in the pond are stirred daily so that the nutrients in the soil dissolve in water for easy uptake by Azolla. 5kg cowdung slurry should be sprinkled in the Azolla nursery at 10 days intervals. Neem oil can be sprayed over the Azolla at 0.5 5 level to avoid pest incidence.

Benefits of Azolla

1. Azolla provides nitrogen bio-fertilization, thus reducing the application of other nitrogen based fertilizers. It also helps to increase yield of paddy by 20-30%.
2. Azolla also helps to suppress weed growth in paddy field.
3. As it decomposes rapidly, its nitrogen, phosphorous and other nutrients are quickly released into the water and made available for uptake by rice plant during grain development in paddy.
4. Dried Azolla can be used as poultry feeds while green Azolla as feeds for fish and livestock.

35. Berkeley Compost [Code No. – 06]

Compost which is being used by farmers since ages is a micro and macro nutrients adding to the soil for its improvement. It positively affects the physical and biological properties of soil. It improves soil structure by lowering the bulk density and increasing the permeability and porosity of the soil. It provides the plant roots more space to breathe and grow. It increases the organic content in soil, humic acid and organic carbon content and, it also reduce pH in sodic soils. Organic content in soil is positively correlated with microbial and crop growth is a balance diet, nutritional food of the soil.

REGULAR/COLD COMPOSTING

1. Placing a variety of organic materials in a compost bin, enclosure or compost pit
2. Leaving it there until it breaks down several months later
3. Slow process
4. Takes about 6-12 months

Hot Composting

1. Produces compost in a much shorter time
2. Benefits of killing weed seeds and pathogens (disease)
3. Breaking down the material into very fine compost
4. Benefits of hot composting over cold composting

Benefits of hot composting over cold composting

	Hot (40-65°C)	Cold (0-40°C)
1.	Will work all year round – which is relevant when composting food waste.	Cold heaps 'stop' in winter (-5 to +5°c). Anything added piles up until spring when the sunshine warms up the heap. Piling up food waste is not an option – it is just a free rat take away.
2.	Hot Composting can take a wider variety of food waste types without causing issues. Also the higher temperature results in water removal – and hence removes a prime cause of mushy / anaerobic food waste).	70% all household food waste is not added to 'cold' compost bins as it is likely to cause issues with odour, rats and flies. Cold compost bins tend to be constructed with open vents and hatches – so any odour not only attracts but also allows access to the food – creating the infamous 'swarm' of flies when the lid is taken off, or even worse finding a nest of rats when the heap is broken open.
3.	Hot composting kills weed seeds faster. The higher the temperature the more seeds are destroyed.	Many seeds will survive in 'cold' composting heaps. The problem is made worse as the seeds are planted in nature's best growing medium - humus / compost. It's not just weed seeds but seeds from melons and tomatoes plus weeds like couch grass and dandelion will also survive and grow.
4.	Hot composting kills pathogens and unwelcome bacteria.	You need to leave cold compost a long time (12-18 months) to achieve the same level of sanitization and bacteria to die off.
5	Herbicides and pesticides are broken down in composting. They are broken down 32 times	The risks of pesticide infection via use of domestic compost is low because the

	faster at 60°c than at 10°c.	concentration and volumes used are low. However the extra security of fast destruction in hot composting is an extra level of security.
6.	A hot heap rarely produces putrid odours. Hot heaps transfer water away from the heap as steam (as long as the waste has free air space which is normally provided by bulking agent).	In a cold heap, water is not evaporated; it has to drain to the ground. This happens slowly and poorly in compost, so it gets water logged and turns anaerobic and putrid. The main solution is not to add 'wet' food waste to cold heaps - most of our diet is foods with 80% water. Cold composting releases VOC more slowly and they do not vaporize as much.
7.	A hot bin will kill fly eggs & larvae - so no swarms of flies or maggots in a hot compost bin. It's too hot at the top for ants, rats, and most things you don't like to see in a heap.	Flies will lay eggs and larvae (e.g. maggots) will be present in a cold heap, and often swarms of flies can come out when lid open.

18 days Compost

It follows the Berkeley Method of Compost preparation. (Berkeley Method was innovated by Professor Robert D. Raabe in University of California in 1970). It is the fastest way to decompose organic material. It is a quick and cost effective method, based on locally available resources. The decomposition happens aerobically, breaking down all the material in only 18 days, providing proper C: N ratio. In colder region it may take 20-22 days.

Requirements for hot composting using the Berkeley method

1. Compost temperature is maintained between 55-65°C.
2. The C:N (carbon : nitrogen) balance in the composting materials is approximately 25-30:1.
3. The compost heap needs to be roughly 1.5m high.
4. Compost is turned from outside to inside and vice versa to mix it thoroughly.

Composting Materials and the Carbon-Nitrogen Balance

1. In the hot composting method, the ratio of carbon to nitrogen in the compost materials needs to be between 25 to 30 parts carbon to one-part nitrogen by weight.
2. This is because the bacteria responsible for the composting process require these two elements, in these proportions, as nutrients to construct their bodies as they reproduce and multiply.

3. Materials that are high in carbon are typically dry, “brown” materials, such as sawdust, cardboard, dried leaves, straw, branches and other woody or fibrous materials that rot down very slowly.

4. Materials that are high in nitrogen are typically moist, “green” materials, such as lawn / grass clippings, fruit and vegetable scraps, animal manure and green leafy materials that rot down very quickly.

5. If ratio of C:N is right in this technique of fast, aerobic (uses oxygen), hot composting, the compost will break down to the same volume.
6. This is in contrast to slow, anaerobic (without oxygen) composting that happens in a compost bin, which drastically reduces in volume as it rots down.

Method of preparation

- Materials needed
  - ✓ Brown matter
  - ✓ Green matter
  - ✓ Cow dung
  - ✓ Water
- Ratio:
  - ✓ Brown : Green: Cow dung (3:2:1)

Steps for preparation

1. Location must be protected from too much sun / heavy rain.
2. Brown or green matter must be chopped to one inch.
3. Make the heap at 1.5m x 1.5m.
4. Pile up according to the ratio and add water at every level.
5. Cover with plastic.
6. On day 5, turn the compost heap over, outside turn to inside, inside turn to outside.
7. Ensure that moisture stays constant.
8. Need optimum temperature of 55-65°C.

9. At 65°C, a white mould spreads through the compost – anearobic thermophilic bacteria.
10. It disappears when the temperature drops and aerobic composting bacteria takes over.
11. Turn the compost heap every alternate day.
12. On day 18, compost gives a fine black humus.

36. Vermicompost [Code No. – 78]

Vermicomposting is a method of preparing enriched compost with the use of earthworms. It is one of the easiest methods to recycle agricultural wastes and to produce quality compost. Earthworms consume biomass and excrete it in digested form called **worm casts.** Worm casts are popularly called as **Black gold.** The casts are rich in nutrients, growth promoting substances, beneficial soil micro flora and having properties of inhibiting pathogenic microbes. Vermicompost is stable, fine granular organic manure, which enriches soil quality by improving its physicochemical and biological properties. It is highly useful in raising seedlings and for crop production. Vermicompost is becoming popular as a major component of organic farming system.

Vermicomposting materials

Decomposable organic wastes such as animal excreta, kitchen waste, farm residues and forest litter are commonly used as composting materials. In general, animal dung mostly cow dung and dried chopped crop residues are the key raw materials. Mixture of leguminous and non-leguminous crop residues enriches the quality of vermicompost.

There are different species of earthworms viz. *Eisenia foetida* (Red earthworm), *Eudrilus eugeniae* (night crawler), *Perionyx excavatus* etc. Red earthworm is preferred because of its high multiplication rate and thereby converts the organic matter into vermicompost within 45-50 days. Since it is a surface feeder it converts organic materials into vermicompost from top.

Important characteristics of red earthworm (Eisenia foetida)

Characters		
Body length	-	3-10cm
Body weight	-	0.4-0.6g
Maturity	-	50-55days
Conversion rate	-	2.0 q / 1500worms / 2 months
Cocoon production	-	1 in every 3 days
Incubation of cocoon	-	20-23days

Types of vermicomposting

The types of vermicomposting depend upon the amount of production and composting structures. Small-scale vermicomposting is done to meet the personal requirement and farmer can harvest 5-10 tonnes of vermicompost annually. While, large-scale vermicomposting is done at commercial scale by recycling large quantity of organic waste with the production of more than 50 – 100 tonnes annually.

Methods of vermicomposting

Vermicromposting is done by various methods, among them bed and pit methods are more common.

Bed method: Composting is done on the pucca / kachcha floor by making bed (6x2x2 feet size) of organic mixture. This method is easy to maintain and to practice (Fig.1).

Fig. 1 Bed method

Fig. 2 Pit method

Pit method: Composting is done in the cemented pits of size 5x5x3 feet. The unit is covered with thatch grass or any other locally available materials. This method is not preferred due to poor aeration, water logging at bottom, and more cost of production.

Process of vermicomposting

Following steps are followed for vermicompost preparation

1. Vermicomposting unit should be in a cool, moist and shady site
2. Cow dung and chopped dried leafy materials are mixed in the proportion of 3: 1and are kept for partial decomposition for 15 – 20 days.
3. A layer of 15-20cm of chopped dried leaves / grasses should be kept as bedding material at the bottom of the bed.
4. Beds of partially decomposed material of size 6x2x2 feet should be made (fig.3).
5. Each bed should contain 1.5-2.0q of raw material and the number of beds can be increased as per raw material availability and requirement.
6. Red earthworm (1500-2000) should be released on the upper layer of bed (fig.4).
7. Water should be sprinkled with can immediately after the release of worms (fig.5)
8. Beds should be kept moist by sprinkling of water (daily) and by covering with gunny bags / polythene (fig.6)
9. Bed should be turned once after 30 days for maintaining aeration and for proper decomposition.
10. Compost gets ready in 45-50 days (fig.7).
11. The finished product is 3 / 4th of the raw materials used.

Fig.3 Bed of raw materials

Fig.4 Red earthworms for use

Fig.5 Watering of beds

Fig.6 Beds covered with gunny bags

Harvesting

When raw material is completely decomposed it appears black and granular. Watering should be stopped as compost gets ready. The compost shout be kept over a heap of partially decomposed cow dung so that earthworms could migrate to cow dung from compost (fig.7). After two days compost can be separated and sieved for use (fig.8).

Fig.7 Harvesting in heaps

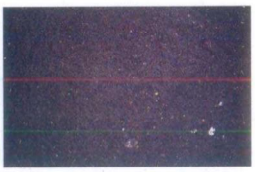


Fig.8 Final product after sieving

Preventive measures

1. The floor of the unit should be compact to prevent earthworms' migration into the soil.
2. 15-20 days old cow dung should be used to avoid excess heat.
3. The organic wastes should be free from plastics, chemicals, pesticides and metals etc.
4. Aeration should be maintained for proper growth and multiplication of earthworms.
5. Optimum moisture level (30-40 %) should be maintained
6. 18-25oC temperature should be maintained for proper decomposition.

Nutrient content of vermicompost

The level of nutrients in compost depends upon the source of the raw material and the species of earthworm. A fine worm cast is rich in N P K besides other nutrients. Nutrients in vermicompost are in readily available form and are released within a month of application.

Nutrient Analysis of Vermicompost

Parameters		Content
pH	-	6.8
OC%	-	11.88
OM%	-	20.46
C / N ration	-	11.64
Total Nitrogen (%)	-	1.02

Parameters		Content
Available N (%)	-	0.5
Available P (%)	-	0.3
Available K (%)	-	0.24
Ca (%)	-	0.17
Mg (%)	-	0.06

Advantages

The following are the advantages of vermicompost :

1. It provides efficient conversion of organic wastes / crop / animal residues.
2. It is a stable and enriched soil conditioner.
3. It helps in reducing population of pathogenic microbes.
4. It helps in reducing the toxicity of heavy metals.
5. It is economically viable and environmentally safe nutrient supplement for organic food production.
6. It is an easily adoptable low cost technology.

Doses

The doses of vermicompost application depend upon the type of crop grown in the field / nursery. For fruit crops, it is applied in the tree basin. It is added in the pot mixture for potted ornamental plants and for raising seedlings. Vermicompost should be used as a component of integrated nutrient supply system.

Crops		**Dose/rate**
Field crops	-	5-6t / ha
Fruit crops	-	3-5kg / plant
Pots	-	100-200g / pot

37. Panchagavya [Code No. – 57]

A concoction prepared by mixing five products of cow. It has the potential to play the role of promoting growth and providing immunity in plant system.

Materials used:

Cow urine - 1ltr
Cow-dung - 1 kg
Milk- 250 ml
Ghee- 50gm
Besan Powder-100gm
Curd- 250ml
Soil- handful
Jaggery- 100gm
Black cloth

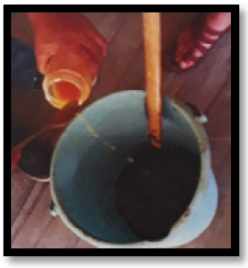




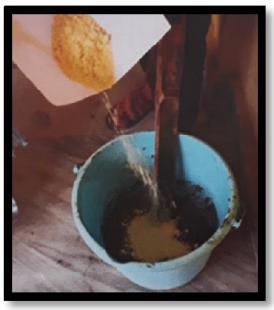



Phases of Panchagavya

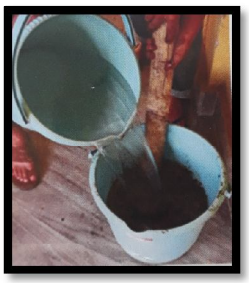
1. In a plastic bucket, the cow dung and ghee are thoroughly mixed and is covered with a black cloth. The mixture is stirred for 2-3 days and kept n a dark place.
2. After 3 days, in the same bucket mix the following ingredients:
    a. Cow urine(1 litre)
    b. Uncooked Milk (250ml)
    c. Curd (250ml)
    d. Beson powder(100gm)
    e. Jaggery (100gm)
    f. Ripened Fruits(2-3)
    g. Soil(handful)
3. After mixing all the ingredients, pour water about 10 lt and stir and cover with the black cloth and keep in a dark place.
4. Stir the mixture every day for 20 days.












Steps to use Panchagavya

a. Take 1litre of Panchagavya and mix with 200litres of water.
b. We can use this mixture for 90days.
c. Spray the soil about 20 litres in 1acre.
d. For the seed and seedlings soak in this mixture for about 20-30 minutes before planting.
e. Spray every 15 days and for plants its best suited to spray for thrice a month.

38. Jeevamrit [Code No. – 37]

A microbial culture, prepared especially from dung and urine of cow is generally advocated for use in organic farming to meet the nutritional requirement of crops.

Materials used:

Plastic bucket- 20lt
Cowdung- 1kg
Cow Urine- 1ltr
Beson Powder- 250-500gm
Jaggery- 250-500gm
Garden soil- handful
Black cloth






Phase of Jeevamrit:

a. Mix all the ingredients in a plastic bucket.
b. Add 10ltr of water and stir and cover it with a black cloth and keep it in a dark place.
c. Stir twice a day for 7 days.

Steps to use Jeevamrit:

a. After preparation the mixture can be used for 3-9 days.
b. Take 1 ltr of jeevamrit and mix with 10 litres of water.
c. The area to be sprayed should be moist.
d. Can be spray every 15 days. Best suited to be sprayed thrice a month.

39. Home Remedies for Management of Insect-Pests & Diseases

Some Common Insect -Pests in Kitchen Garden

Mixture of cowdung, cow urine, chilli and garlic

1. Dug a pit as required, in which cowdung, cow urine, chilli and garlic are mixed and kept it for decomposition.
2. The decomposed mixture is then spray in the kitchen garden.
3. 2-3 spray is done in each season

Use of silkworm excreta

1. The excreta is allow to dry and make into a fine powder and a pply to the field (paddy and vegetable field)
2. The excreta is insecticidal for some pest while repelling others.

Use of garlic extract

1. Make fine garlic paste and extract the juice from it using muslin cloth.
2. Add 50 ml of water to the extract and immediately spray to the field.
3. Always used fresh mixture for every spray.

Use of tobacco extract

1. Soak tobacco leave in 50 ml of water or crush the leave into fine paste and mixed it well with 50 ml of water.
2. Spray immediately to the vegetable garden

Use of household ash

1. Household ash is sprayed in and around the vegetables crop in the kitchen garden to protect from pests and diseases.

Use of bio-agents

1. Drench on seed beds or spray *Viricon - L* @ 10 15 spoons in 16 liter of water for management of wilting and rot of the vegetable crop.
2. Spray of Helicon-L @ 10-15 spoon in 16 liter of water for management of leaf eating caterpillar in vegetables plant.

Use of trichocard

1. Use of *Trichogramma brassicae* for management of cabbage butterflies in cole crops.
2. Use of *T. brassiiiensis* for management of fruit and shoot bore in tomato.

Barriers

Barriers are physical structures put in place to prevent a pest from reaching a plant. They keep pests away from a plant but do not kill them.

Crawling insects

1. Cut the top off a transparent plastic bottle and place it firmly into the ground, over a young plant. This stops pests such as slugs from reaching the plant.

Climbing insects

1. To help protect trees from attack by insects, grease bands can be used.

Termites

1. Digging a 70-100cm trench around buildings and nurseries can prevent attack from subterranean species of termites.

Bait traps

Cutworms

Method one

1. Mix equal quantities of hardwood sawdust, bran, molasses and enough water to make the solution sticky.
2. Spread around the base of the plants in the evenings. The molasses attract the cutworms and as they try to pass through it they get stuck. The substance dries out in the sun and the pest dies.

Method two

1. Mix 100 grams (g) of bran, 109 of sugar, 200 ml of water, 5g of pyrethrum powder. Spread around the base of the plants. The cutworms eat the substance and die.

Light traps

1. Light traps are set up at night and attract a variety of flying insects including moths, mosquitoes, chafer beetles, American bollworms, army worms, cutworms, brown rice plant hopper, green rice leaf hopper, rice black bugs, rice gall midges, rice stem borers and tomato hornworms.

Use of pheromone trap

1. Use of luci lure and heli lure for management of fruit and shoot borer in brinjal and tomato respectively.
2. Use of cue lure for management of fruit fly in cucurbits crop.

Use of trap crop

1. Planting of marigold flower along with vegetable crops reduced the incidence of aphids and thrips.
2. Planting of mustard after every 5-10 rows of cabbage or cauliflower.
3. Trap cropping of mustard and radish reduced the incidence of cabbage borer.
4. Intercrop cabbage and tomato reduced infestation of pests in cabbage.

Use of sticky trap

1. Use of yellow sticky trap for management of aphid and white fly.

Use of common salt

1. Distribute or spread common salt around the plant for management of snail and slug.

Use of vinegar

For management of fruit fly

1. Take 1 cup of water, a half a cup of apple cider vinegar, a quarter of a cup of sugar and 1 tablespoon of molasses and mixed together.
2. Take old tin cans without their lids and make two holes in opposite ends for wire handles.
3. Attach the handles and add an inch of the mixture to each can and hang 2 - 3 tins in each tree.

For management of fungal diseases or black spot

1. Take 2 tablespoons of white vinegar and mix it with 4 litres of compost tea and spray to the garden plant.
2. Take 3 tablespoons of cider vinegar, and mix it with 4 litres of water to control those fungal diseases.

For management of powdery mildew

1. Take 2-3 tablespoons of cider vinegar and mix with 4 litres of water and spray your plants.

For management of slug and snail

1. Vinegar acts as a poison to the slugs because, if you spray slugs with it directly, they will die. You can treat snails in exactly the same way.

Fruit fly baits

Baits for fruit fly that can be poured into the traps:

1. Mix 1 teaspoon of pyrethrum powder, 250g of honey, a few drops of vanilla essence, 250g of orange or cucumber peel or pulp and 10 litres of water.

Use of corn meal

1. Put a tablespoon or two of cornmeal in a jar and lay it on its side wherever there is slug activity. The slugs love this stuff and after eating it they die.

Use of baking soda

1. Mixed one spoon of baking soda in 3 liter of water
2. Add one or two drop of liquid soap.
3. Add tea spoon of vegetable oil
4. Spray the solution to the plant.
5. This is effective against powdery mildew in the plants

40. Zero Budget Natural Farming (ZBNF) [Code No. – 81]

HISTORY

Mr. Subhash Palekar studied natural system and verified natural processes of the forest on his farm for six years, since 1989 to 1995. There were about 154 research projects during these six years of research work. After six years of verified research work, he got the package of technique about Zero Budget Natural Farming; which he is giving to the farmers throughout India.

DEFINITION

ZERO BUDGET NATURAL FARMING (ZBNF) or holistic agriculture is a method of agriculture that counters the commercial expenditure and things required for the growth of plant are present around the root zone.

Palekar's vision

1. The model eliminates the cost of fertilizers, pesticides and seed and greatly reduce the incentive borrow, one of the chief causes for farmer suicides in the country. Hence, its evocative title ZERO BUDGET NATURAL FARMING.
2. He believes in a method of cultivation which makes the already existing nutrients in the soil such as phosphate, potash, zinc, and calcium available in absorbable form by the plants.

Some unique quality of ZNBF

3. In the ZERO BUDGET NATURAL FARMING nothing has to be purchased from the outside. All the things required for the growth of the plants are available around the root zone of the plants.
4. 98 to 98.5% nutrients are taken from air, water and solar energy.
5. Remaining 1.5% nutrients taken from the soil are also available free of cost as it is taken from the prosperous soil which is enriched with these nutrients.

PRINCIPLES of ZBNF

1. Natural Input

Natural farming does not require chemicals inputs or organic compost like vermi culture but promotes a natural catalyst of biological activity in the soil and natural protection from diseases

2. Low Input Farming

The production cost for the farmer is zero as no input needs to be purchased. As 1.5 to 2.0% of the nutrients are taken from the soil by the plants, there is no need to add fertilizers.

3. MULCHING

a. It is necessary to create the micro-climate under which micro-organisms can well develop, that is 25 to 32□ temperature, 65 to 72 % moisture.

b. It conserves humidity of the soil, cools it and protects its micro-organisms.

c. It promotes humus formation, suppresses weeds and maintain the water requirement of crops.

4. Multi-cropping

Multi-cropping is a good way to minimize the risk for the farmer who is able to enjoy continuity of yield throughout the year. In case of a crop's failure he can also rely on the other crops. It has expanded farmers' income sources.

Importance of desi cow in zbnf

a. One gram of desi cow dung contains 300 to 50 crores of beneficial effective microbes.
b. All Indian cow breeds are suitable for ZBNF.
c. Dung and urine from one desi cow is sufficient to cultivate 30 acres of land in ZBNF
d. Cross Bred Jersey & Holstein Friesian cows are not suitable for ZBNF, there is more pathogens in their dung and urine.

FOUR WHEELS OF ZNBF

1. **Jivamrita/jeevamrutha** is a fermented microbial culture. It provides nutrients, but most importantly, acts as a catalytic agent that promotes the activity of microorganisms in the soil, as well as increases earthworm activity; During the 48 hour fermentation process, the aerobic and anaerobic bacteria present in the cow dung and urine multiply as they eat up organic ingredients (like pulse flour). A handful of undisturbed soil is also added to the preparation, as inoculate of native species of microbes and organisms. Jeevamrutha also helps to prevent fungal and bacterial plant diseases. Palekar suggests that Jeevamrutha is only needed for the first 3 years of the transition, after which the system becomes self-sustaining.

How to prepare jeevamrutha: Put 200 liters of water in a barrel; Add 10 Kg fresh local cow dung and 5 to 10 liters aged cow urine; Add 2 Kg of Jaggery (a local type of brown sugar), 2 Kg of pulse flour and a handful of soil from the bund of the farm. Stir the solution well and let it ferment for 48 hours in the shade. Now jeevamrutha is ready for application. 200 liters of jeevamruta is sufficient for one acre of land.

Jeevamrutha Application: Apply the jeevamrutha to the crops twice a month in the irrigation water or as a 10% foliar spray.

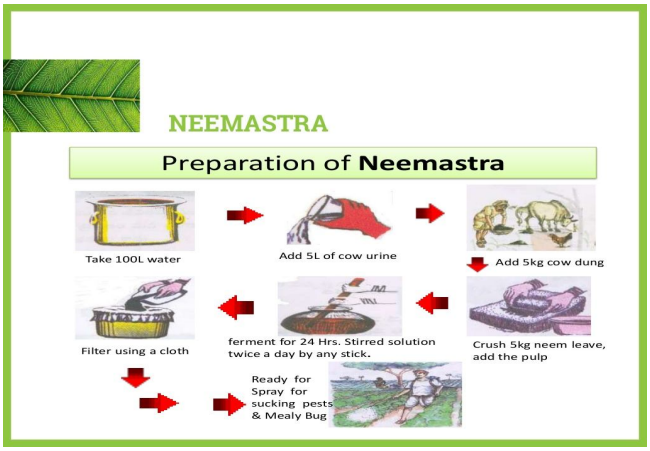
2. **Bijamrita/beejamrutha** is a treatment used for seeds, seedlings or any planting material. Bijamrita is effective in protecting young roots from fungus as well as from soil-borne and seedborne diseases that commonly affect plants after the monsoon period. It is composed of similar ingredients as jeevamrutha - local cow dung, a powerful natural fungicide, and cow urine, a strong anti-bacterial liquid, lime, soil.

Bijamrita Application as a seed treatment: Add Bijamrita to the seeds of any crop: coat them, mixing by hand; dry them well and use them for sowing. For leguminous seeds, just dip them quickly and let them dry.

3. Acchadana - Mulching. According to Palekar, there are three types of mulching:

a. **Soil Mulch:** This protects topsoil during cultivation and does not destroy it by tilling. It promotes aeration and water retention in the soil. Palekar suggests avoiding deep ploughing.
b. **Straw Mulch:** Straw material usually refers to the dried biomass waste of previous crops, but as Palekar suggests, it can be composed of the dead material of any living being (plants, animals, etc). Palekar's approach to soil fertility is very simple – provide dry organic material which will decompose and form humus through the activity of the soil biota which is activated by microbial cultures.
c. **Live Mulch (symbiotic intercrops and mixed crops):** According to Palekar, it is essential to develop multiple cropping patterns of monocotyledons (monocots; Monocotyledons seedlings have one seed leaf) and dicotyledons (dicots; Dicotyledons seedlings have two seed leaves) grown in the same field, to supply all essential elements to the soil and crops. For instance, legumes are of the dicot group and are nitrogen-fixing plants. Monocots such as rice and wheat supply other elements like potash, phosphate and sulphur.

4. Whapasa - moisture: Palekar challenges the idea that plant roots need a lot of water, thus countering the over reliance on irrigation in green revolution farming. According to him, what roots need is water vapor. Whapasa is the condition where there are both air molecules and water molecules present in the soil, and he encourages reducing irrigation, irrigating only at noon, in alternate furrows ZBNF farmers report a significant decline in need for irrigation in ZBNF.



Other important principles of ZBNF and points to note

a. **Intercropping** makes the ZBNF system budget less. The minimum costs that are involved in this system are sourced by the income from intercrops.

b. **Countour and bunds** have to be made for preserving rain water and to attain maximum produce from different crops.

c. **Earthworm species** are revived from the deep soil by the use of organic matter rather than using vermi compost.

d. **Cow dung** from the humped cow is expected to have high concentration of microorganism and proves beneficial for farm.

IMPACT OF THE ZBNF SYSTEM

a. The ZBNF benefits the agriculture as well as other social and economic zones. A survey has clearly outlined the improvements in yield, soil, seed quality, income, health and autonomy at household level.

b. ZBNF recognises farmers with less farmland area and introduces them a specific crop model.

c. The system of farming improves the nutritional value and yield of the produce thereby contributing to the food security in the country.

d. ZBNF helps the country progress on the Sustainable Development Goals(SDG)by reducing the carbon dioxide emissions at different stages in he agriculture sector.

How can ZBNF Address the Agrarian Crisis

a. The yield in this method goes up over a period of time and also crop productivity and farmers' income have doubled.

b. Additionally, using ZBNF techniques, one can convert even most infertile land into fertile one.

c. Our country has 235 crores acre of farmland and in 2015 , our food production was 25 crore metric tonnes. The area of cultivation is not going to increases, but India's population is estimates to hit 162 crore by 2050 and we want 50mt grains to feed the people. S, if we want to increases the food grain production; we have to opt for ZBNF.

HOW MUCH LAND IS REQUIRED TO START ZBNF??

a. Anyone who is having half an acre of land can start ZBNF.

b. But what we have to ensure is to select crop based on what farmers in our area had been practicing. Local varieties of rice and other crops give better yield.

CONCLUSION

a. Savings on cost of seeds, fertilizers and plant protection chemicals have been substantial.

b. Because of continuous incorporate of organic residues and replenishment of soil fertility. Helps to maintain the soil health.

c. The new system of farming has freed the farmers from the debt trap and it has instilled in them a renewed sense of confidence to make farming an economically viable venture.

41. **Arecanut** [Code-94]

Areca catechu

Garo: Gue

Arecanut is extensively cultivated in the tropical region. It is mostly confined to 28° North and South of the equator. It grows within a temperature range of 14°-36° C and temperature below 10°C and beyond 40°C adversely affects the crop. Due to susceptibility to low temperature, the palms do not perform well at altitude of 1,000 m above mean sea-level. It requires ample supply of soil moisture and plentiful of rainfall throughout the year (1,500-5,000 mm). It is sensitive to drought and in areas with low rainfall (< 750 mm / year), irrigation is necessary.

Soil: It can be grown in a variety of soils. The soil should be well drained without high water table.

Spacing: 2.7mX2.7m

Selection of mother palms: Select mother palms showing earliness in bearing and high percentage of fruit set. It is preferable to select palms with shorter internodes, more number of leaves on the crown and producing at least 4 bunches in a year.

Selection of seed nuts: Select fully tree-ripen nuts from the middle portion of the middle bunch on the tree. Heavier nuts give higher germination percentage and produce vigorous seedlings. The nuts which float vertically with the calyx end pointing upwards when allowed to float on water are preferred. The selected bunches are lowered by means of rope and shown without delay.

Nursery techniques: Sow selected seed nuts soon after harvesting in nursery beds prepared under shaded condition with the stalk end up and with a closer spacing of 5-6 cm. Cover the seed nuts with sand and irrigate daily. Germination starts in 45 days and continues up to 3 months. Good quality seeds give 90-98% germination. Transplant 90 days old sprout having 2-3 leaves into the secondary nursery. Prepare secondary nursery beds with 150 cm width and of convenient length. Apply Farmyard Manure (FYM) @ 5 tonnes / ha as basal dose. Transplant sprouts at a spacing of 30 cm X 30 cm. Provide shade by growing banana, or by raising artificial pandals. Plant banana in advance at a spacing of 2.7m X3.6 m as shade crop. Provide irrigation during hot and dry months. Periodical weeding and mulching are necessary.

Selection of seedlings: Select good seedlings for planting in the main field when they are 12-18 months old. Seedlings with maximum number of leaves and maximum height should be selected for planting. Alternatively, a selection index can be worked out by multiplying leaf number by 40 and subtracting the seedlings height and select seedlings with higher index values.

Plant characters like girth at collar one year after transplanting and number of nodes [1] years transplanting are highly correlated with yield. Plants with less than 20 cm girth one year after transplanting and less than 4 nodes 2 years after transplanting should be discarded.

Field Planting: Select site with deep (not less than 2 m), well-drained soil, without high water table and provision for irrigation. Arecanut palm is very delicate and cannot withstand extremes of temperature and exposure to direct sun. Plant tall, quick-growing shaded trees on the southern and western sides of the plantation to provide protection from the sun –scorching. Soil depth and water table are important aspects to be considered while selecting site, since it determines the development of root system.

Manures: Apply green leaf or compost @ 12 kg / palm / year from the first year of planting onwards, during September-October.

Irrigation: Arecanut palm is very sensitive to drought. The palm should be irrigated during hot and dry weather at 4-7n days' intervals @ 175 litres / palm depending on the soil type. When there is shortage of water, follow drip irrigation. Application of organic mulch around the base of the palm helps to conserve soil moisture. Proper drainage should be ensured by constructing drainage channels, 25-30 cm deep, for every row of palms. They are to be cleared at the beginning of monsoon every year.

Intercropping: Arecanut as a sole crop does not utilize fully the natural resources and practically wasting 70% of the land area and 40% of the solar radiation and is ideal for intercropping. Cocoa is an ideal crop for mixed cropping with arecanut and this can be planted in pits dug 2.7m apart in between alternate rows of arecanut, in the centre. In all cases, intercrops should be manured adequately and separately. Mutistoried cropping with black pepper and pineapple is followed in some areas of Garo Hills like Bikonggre under Dadenggre Block.

Harvesting: Arecanut starts flowering from 3-4 years after planting. Matured nuts are usually harvested during March –April.

Uses: Areca nut and the plant as a whole is used widely in India and South Asia as: a masticator for chewing purposes, vegetable, medicine, stimulant, timber, fuel wood, clothing, wrapping, lubricant, tannin and so forth. The nut is chewed with the betel leaf as it has a stimulating effect.

42. IMPROVED PRODUCTION TECHNOLOGY OF RAMIE [Code- 95]

Ramie:: *Boehmeria nivea*

Local name: Kilkra

Ramie is a semi-perennial shrub belonging to the family Urticaceae and it produces the strongest vegetable fibre that makes excellent raw materials for textile industries. Ramie grows well under warm humid climate. It requires a well distributed annual rainfall of 1500-2500mm. The crop can thrive under relatively dry condition but growth is severely hampered and irrigation is needed to get optimum growth. The favorable temperature for growth ranges between 25 to 31^{0}C with the maximum of 35^{0}C. The optimum RH is 80% and it should not be below 21%.

Soil: Deep fertile loamy or sandy soils are suitable for successful cultivation of the crop. The optimum pH is 6-7 though the crop can well withstand mild acidity. If pH is 4-5, lime is to be applied depending upon lime requirement of the soil. Soil should be rich in organic matter.

Cultivation: Land is to be plough 2-3 times and leveled to facilitate drainage. The plot should be free from clods and weeds. In flat planting, generally small furrows of 5-7 cm depth are opened with wheel hoe and rhizomes are placed horizontally and covered with soil. Ridge and furrow method of planting is preferable over flat planting as the ridges protect the rhizomes from water stagnation. Under rainfed condition planting of ramie can be started from 2nd week of April. Under irrigated condition planting can be done throughout the year except the winter months. Rhizomes taken from 4-5 year old plantations are suitable for commercial plantations. Freshly dug rhizomes should be kept in shade and covered with gunny bags or sprinkled with water to prevent drying.

Seed rate: 800-900Kg /ha rhizomes. Alternate planting materials like stem cutting can also be used but it takes more time to establish than the rhizomes.55000-60000 cutting /ha

Spacing: 30X60cm

Stage back: The growth of ramie during winter months is retarded and not uniform and the canes are not suitable for fibre extraction. Thus in a rainfed plantation, the winter crop is cut close to the ground during March/April with onset of pre-monsoon showers, for uniform growth of subsequent crop. This operation is called stage back and is extremely important for getting good fibre yield in subsequent cuts.

Water Management: During dry months irrigation is required for crop growth. Soil moisture can be conserved by mulching.

Weed management: Weeding is essential during the establishment phase and also during the initial growth after each cut.

Harvesting: Under rainfed condition usually 4 cuts may be taken in a year at 50, 45, 45, and 50 days interval respectively. Harvesting is done manually by cutting the stalks near ground level.

Signs of maturity:

1. Lower part of the stalk turns brown or coppery in colour.
2. Lower leaves turn yellowish and begin to shade

3. Apical part of the plant shows bending tendency.
4. New sprouts just begin to appear above the ground.
5. The bark of the stem can easily be peeled out from the stick.

Leaves of the harvested canes are to be defoliated in the plot itself as it contains high amount of nutrient.

Extraction: Fibre is extracted from the harvested defoliated canes by decorticator machine.

Fibre yield: A good ramie crop on an average produces 16-22q of undegummed fibre/ha/year from 4-5 cuts.

Degummimg: It is the process of removal of gum either by chemical method or by microbial method.

Chemical degumming: The fibre is to be kept in water for a day. The wet fibre is boiled in 1% NaOH solution for 30 minutes twice. The fibre is then washed thoroughly in water and subsequently with 6% acetic acid to neutralize alkalinity. The resultant fibre is light yellowish and to get white colour, fibre is to be bleached with H_2O_2, 0.5% sodium hypochlorite solution etc. Gum content of the fibre is reduced to 3-4%.

Microbial degumming: The fibre can be degummed by using pectinolytic bacteria *(Bacillus pumilus)* isolated from soil and subsequently treated with mild (0.1%) alkali solution which brings the gum content to about 4-5%.

Uses: The use of ramie fibre depends primarily on its gum content. If gum content is less than 4%, it can be used for manufacturing of fabric. It can be blended with natural fibres like cotton, silk, wool and also with synthetic fibres to produce yarns. Ramie fibres containing more than 6% gum are used for making hose pipe, water bags, commercial canvas etc. Ramie plants can also be used for manufacturing of bio-composites, composites and particle boards. The cellulose obtained from ramie fibre has high purity and used extensively in pharmaceutical and chemical industries.

43. Ecological Engineering In IPM [Code-96]

INTRODUCTION: Ecological engineering is defined as the design of sustainable ecosystem that integrates human society with its natural environment for the benefit of both. In IPM, ecosystem is designed to manipulate the main crop with trap crops, repellents, attractants etc. so that the incidence of pests and diseases will be reduced. Since our state is moving towards organic farming, understanding the agro-ecosystem and planning and designing of crop ecosystem is very important.

AIM: To reduce insect pest a by growing trap crops and introducing predators / defenders.

OBJECTIVES: At the end of the training the farmers will be able to

1. Select and grow different trap crops, repellents and attractants
2. Identify pests and defenders
3. Design and grow their own vegetable plots and field crops

Methodology: Group discussion, brainstorming.

Do you know engineers? What do they do / what is their work?

Since farmers are experts in growing vegetables and field crops it is not necessary to train them regarding the package of practices for different crops. The need of the hour is the management of insect pest. When we talked about insects the farmers think that all the insects are pest. Very few inputs are needed to make them realised that all insects are not pests and some insects are predators or defenders that survive on other insects. During the discussion the farmers were asked to name few insects which they have seen preying on other insects. It is surprising to know that they could name many of the defenders that are found in their field e.g spiders, lady bird beetles, wasps, praying mantis, water striders, frogs, etc and birds like owl , Drango etc. The farmers were told about the defenders / predators and the different pests they attack as follows:

Sl. No	Predators/pathogens/ parasites	Pests attacked
1.	Spiders	Flies, mosquitoes, moths, butterflies
2.	Ladybird beetle larvae	Ahpids, spider mites, scale insects, whiteflies and lepidoteran eggs and small larvae.
3.	Praying mantis	Grasshoppers, crickets, flies, leafhoppers, mosquitoes, butterflies etc.
4.	Water striders	Mosquitoes, larvae of stem borer and other insects.
5.	Dragonflies	Gnats, mayflies and other small flying insects
6.	Trichogramma	Eggs of noctuids
7.	Tachinid flies	Larvae of noctuids
8.	Damsel bug	Lepidoptera eggs and larvae, mites and mired eggs
9.	Beuvaria bassiana	Helicoverpa, loopers, caterpillars,armyworms and pod sucking bugs.
10.	Owl	Rodents and snakes

After discussing about predators/defenders, the farmers were asked about the different crops that were susceptible to insect pests. They named different crops like laisak (rapeseed & mustard), sesamum, radish etc. And those crops are used as trap crops/ sacrificial crops.

List of some important trap crops

Trap crop	Main crop	Method of planting	Pest controlled
Alfalfa	Cotton	Strip intercrop	Bugs
Basil and marigold	Garlic	Border crop	Thrips
Castor plant	Cotton	Border crop	Heliotis sp.
Chinese cabbage, mustard and radish	Cabbage	Planted in every 15 rows of cabbage	Cabbage webworm, flea hopper, aphids
Beans and other legumes	Corn	Row intercrop	Leafhopper, leaf beetles, stalk borer, armyworm
Chick pea	Cotton	Block trap crop at 20 plants/sq m	Heliotis sp.
Collards	Cabbage	Border crop	Diomondback moth
Corn	Cotton	Row intercrop, planted in every 20 rows of cotton or every 10-15 m	Heliotis sp.
Cowpea	Cotton	Row intercrop in every 5 rows of cotton	Heliotis sp.
Desmodium	Corn, cowpea, millet, sorghum	Row intercrop	Stemborer, striga
Green beans	Soybean	Row intercrop	Mexican bean beetle
Hot cherry pepper	Bell pepper	Border crop	Pepper maggot
Indian mustard	Cabbage	Strip intercrop in between cabbage plots	Cabbage head caterpillar
Marigold (French and African marigold)	Solanaceous, crucifers, legumes, cucurbits	Row/strip intercrop in between cabbage plots	Cabbage head caterpillar, slugs, thrips, nematodes
Napier grass	Corn, rice	Intercrop, border crop	Stemborer
Nasturtium	Cabbage	Row intercrop	Aphids, flea beetle, cucumber beetle, squash vine borer
Okra	Cotton	Border crop	Flower cotton weevil
Onion and garlic	Carrot	Border crops or barrier crops in between plots	Carrot root fly Thrips
Radish	Cabbage family	Row intercrop	Flea beetle, root maggot
Rye	Soybean	Row intercrop	Corn seedling maggot
Sesbania	Soybean	Row intercrop at a distance of 15 m apart	Stink bug
Sickle pod	Soybean	Strip intercrop	Velvet bean caterpillar, green stink bug
Soybean	Corn	Row intercrop	Heliotis sp.

Sudan grass	Corn	Intercrop, border crop	Stemborer
Sunflower	Cotton	Row intercrop in every 5 rows of cotton	Heliotis sp.
Tansy	Potato	Intercrop	Colorado potato beetle
Tobacco	Cotton	Row intercrop, planted in every 20 rows of cotton	Heliotis sp.
Tomato	Cabbage	Intercrop (tomato is planted 2 weeks ahead at the plots' borders)	Diamondback moth
Vetiver grass	Corn	Perimeter crop	Corn stalk borer
Nettles		Border crop	aphids

So, comprehensive organic pest control involves:

- **Diverse planting** to confuse pests
- **Including flowers** to attract beneficial insects
- **A few trap crops** targeted at pests of your main crop
- **Crop rotation** to avoid pests overwintering in the soil.

Timing: When to grow??? Trap crops should be well established before the cultivation of the main crop and we should also keep in mind the incidence of different pests at different seasons.

TARGET----SPECIFIC PESTS----GROW---------SPECIFIC TRAP CROPS

Since the farmers have learnt about the defenders and trap crops, it is time to put it into practice by planning and designing their own vegetable gardens and field crops. In simple words ecological engineering is the manipulation of field crops and vegetables by growing trap crops along with the main crop in order to decrease insect pests incidence without using any chemicals.

44. Rodent Pest Management [Code-97]

Rodent pest management is normally aimed at application of poison baits in order to kill the rodents which is often a failure. In order to manage the rodents successfully, study of their behavioural traits is important.

Major behaviours of rodents:

1. Fossoriality
2. Nocturnality
3. Exploration
4. Thigmotaxis
5. Neophobia
6. Bait shyness
7. Rodenticide resistance
8. Reproductive bouncing
9. Migrality

Fossoriality: Except most of the squirrels and house rats, rodents are fossorial.

- They live in burrows / crevices.
- Constant environmental conditions are maintained inside the burrows, facilitated by the soil.
- The depth normally depends on the atmospheric temperature.

Nature of rodent burrows:

- Porcupines – make crevices between rocky areas; the crevices are normally tapering; complex of crevices due to gregarious living.
- Bandicoots – scooped soil exists before the burrows with soil pebbles.
- Soft furred field rat – vertical burrow, which extends laterally
- Gerbils – burrow complexes

Nocturnality:

- Most of the rodents are nocturnal in habits.
- The spontaneous activity starts at evening hours after sunset and have exploration, feeding and feeding rhythms; the activity will be minimize by 9.30 pm.
- Again they become active in early morning having exploratory and feeding activities.
- Crepuscular (Dawn & Dusk).

Exploration:

- Rodents have a habit of checking the environment during the spontaneous activity period.
- This is to guard the area where they live to check any incursions or change in the environment
- This is an inborn instinct of all rodents

Thigmotaxis:

- Rodents normally move aligning vertical surfaces.
- In crop fields they move at the base of the bunds and hardly move on the bund.
- Hence, the baits placed on the bund are not accepted
- In storage and domestic situations, they move aligning the walls**.**

Neophobia:

- During the exploration, if they observe any change in the environment, they develop new object reaction
- If it is a trap , they will not enter in side.
- If it is food material, they will not eat readily the food; they mark the food and taste the food.
- Hence, if poisoned baits are given, the behavior affords protection to avoid the bait consumption.
- Neophobic periods:
  R. *rattus* – 3 days
  B. *bengalensis* – 1 day
  M. meltada – 5 days
  T. Indica – 3 days

Bait shyness:

- Sub lethal doses of acute rodeticide will not kill the rodents, but the minute quantities of Phophine generated in stomach will give stomach disturbance.
- Rodents will associate this discomfiture with bait material ate.
- Consequently they avoid eating the food item- BAIT SHYNESS.
- It is temporary phenomenon
- Persistent periods:

  R. *rattus* – 75 days

  B. *bengalensis* – 21 days

  M. meltada – 135 days

  T. Indica – 75 days

Rodenticide resistance:

- Chronic rodenticides are reported to result in development of resistance over a period of time.

Reproductive bouncing :

Normal Breeding	Abnormal breeding
▸ Sex ration (M:F)- 1:1 ▸ Avg. Litter size – 6 ▸ Post partum oestrous- 90 days. ▸ Maturity period- 90 d ▸ This is seen in normal un-disturbed agrarian ecosystems.	▸ Sex ration (M:F)- 1:2 ▸ Avg. Litter size -20 ▸ Post partum oestrous- 2 days. ▸ Maturity period- 75 d ▸ This is seen during unexpected favourable climatic situations.

BREEDING PROFILES

Normal

Abnormal

Migrality:

- Rodents inherently have migrality - movement in search of food sources
- Emigration – outward movement after the harvest in search of food available areas
- Immigration – inward movement of rodents to the crops under establishment

INTEGRATED RODENT PEST MANAGEMENT:

1. Cultural practices - Deep Ploughing and Trimming of field bunds
2. Mechanical practices – Employing local traps
3. Smoking the rat Burrows
4. Flooding of the burrows
5. Biological management: Keeping bird perches in the field. Barn owl, spotted owl, snakes and cats are good predators of rodents. So in order to manage the rodent population we need to preserve and increase the population of owls instead of hunting them.

45. Preparation of botanical pesticides [code- 98]

1.Neem Seed Kernel Extract (NSKE 5%):

- ✓ Take 50 g of powdered neem seed kernels soak it in one litre of water for 8 hours and stir the contents often.
- ✓ Filter the contents through muslin cloth. Make the filtrate to one litre.
- ✓ Add 1ml teepol or triton or sandovit or soap water (2%) and spray .

- **Neem oil (1%) emulsion :**

- ✓ **Mix thoroughly 10 ml of crude neem oil with 1 ml of teepol.**
- ✓ **Add this mixture to one litre of water. Stir vigorously for 5 minutes and spray**

- **Preparation of neem seed bitters :**

- ✓ **Soak 250 g powdered neem seed kernels in one litre of water for 12 hrs.**
- ✓ **Stir the contents often. Filter, first with muslin cloth and through whatman no.4 filter paper using suction pump.**
- ✓ **Dehydrate filtrate in freeze drier until crystalline form of NSB is obtained.**
- ✓ **Recovery rate of NSB is 15-20%. NSB is highly hygroscopic, store in airtight containers.**

- **Pongamia seed extract (5%) :**

✓ **Take 50 g of pongam seed powder in muslin cloth and soak it in one litre of water for overnight.**

✓ **Squeeze the pouch and filter the solution.**

✓ **To the filterate add two ml soap solution, stir well and spray on the infested plants**

- **Anonaine :**

✓ **Custard apple (*Anona squamosa*) – Thrash the seeds and mix with water.**

✓ **Use as spray against aphids, ants and other insects.**

- **Nicotine :**

Tobacco (*Nicotiana tabacum*) – Boil the midribs and stems in water for a few minutes or soak for 3-4 days. Let it cool.

- **Chrysanthemum :**

Grind the dried flowers. Mix with water.

Proportion will be 6-7 tablespoons of dried ground flower to 1 gallon of water

Speaking of Home Recipies!

Coriander Spray	200 g crushed seed + 1 l water. Boil for 10 min.	Dilute extract 2 l water. Spray	Spider mites
Onion bulb extract	85 g chopped onion + 50 ml mineral oil + kerosene. 24 hrs	1 part emulsion + 19 parts water	White flies
Marigold & Chilli extract	500 g whole plant + 10 hot chillies + 15 lit water. Over night soaking	1 : 21 parts + 1 tsp soap per litre	Most Agril pests
Turmeric rhizome extract	20 g shredded rhizome + 200 ml cow urine + 2-3 l water 10 ml soap	24 hrs soaking. Dilute with 2-3 l water + soap	Aphids, caterpillars, red spider mite
Chilli custard apple neem extract	25 g dried chilli+100 g *Anona leaves* + *50g neem fruits*	Grind , soak separately, blend it, filter it, Make it to 5 liters and spray	Aphids, leaf rollers, red scales, spotted beetles

SYNERGISTIC EFFECTS OF BOTANICALS

- Synergistic effect of neem seed kernel suspension on organophosphorus, carbamate and synthetic pyrethroids has been reported

- Neem oil synergized malathion and monocrotophos at 1 to 5 ratio against the red flour beetle

Insect Resistance to Botanicals

- Botanical extracts contain active ingredients of diverse chemical nature
- Very low probability that two extracts would always be identical
- Even if all the same compounds are found in the extract, concentrations almost always will be different
- Insect resistance takes longer to develop to a mixture of natural active compounds than to any one individual component. Ex Green Prach Aphid.

46. Agro Eco System Analysis [Code- 99]

INTRODUCTION:-

Agro-ecosystem analysis (AESA) is a methodology for zoning and analysing agricultural systems in order to plan and prioritise research and development activities in the fields of agriculture and natural resource management. It uses a holistic or systems approach to gather bio-physical and socio-economic information and, within the ecosystem, to identify key issues or problems that is useful for management of different crops. It is a thorough analysis of an agricultural environment which considers aspects from ecology, sociology, economics, and politics with equal weight. The health of a plant is determined by its environment. This environment includes abiotic factors (i.e. sun, rain, wind and soil nutrients) and biotic factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance, which exists between herbivore insects and their natural enemies. If we understand the whole system of interactions, we can use this knowledge to reduce the negative impact of pests and diseases.

Decision making in Integrated Pest Management requires a thorough analysis of the agro-ecosystem. Participants in IPM training will have to learn how to observe the crop, how to analyze the field situation and how to make the proper decisions for their crop management. This process is called the Agro-Eco-System Analysis (AESA). In short, **AESA is a tool of pest management which is based on ecological principles and involves integration of different components for the production of healthy crop and maintain sustainable crop production.**

Practices in AESA based management

AESA methodology involves four (4) steps:

1. Field observation in small group
2. Drawing
3. Discussion in small groups & analysis
4. Presentation

Steps of AESA methodology:

A. Field Observation

1. Go to the field in groups. Enter the field at least 5 ft. away from the bund Walk across the field and choose 10 plants randomly. Observe keenly each of these plants and record your observations:
2. Plant: observe the plant height, number of tillers, crop stage, deficiency symptoms, etc.
3. Pests: observe and count pests at different places on the plant.
4. Defenders: observe and count parasites and predators.
5. Diseases: observe leaves and stems and identify any visible disease symptoms.
6. Rats: count numbers of plants affected by rats.
7. Weeds: observe weeds in the field and their intensity.
8. Water: observe the water situation of the field.
9. Weather: observe the weather condition.

B. Drawing:

First draw the plant with actual number of branches/ leaves etc. at the centre on a chart. Then draw pests on left side and defender on the right side. Indicate the soil condition, weed

population, rodent damage etc. Give natural colours to all the drawing, for instance, draw healthy plant with green colour diseased plant / leaves with yellow colour. While drawing the pests and the defenders on the chart care should be taken to draw them at appropriate part of the plant, where they are seen at the time of observation. The common name of pest and defenders and their population count should also be given along with diagram. The weather factor should be reflected in the chart by drawing the diagram of sun just above the plant if the attribute is sunny. If cloudy, the clouds may be drawn in place of sun. In the case of partially sunny, the diagram of sun may be half masked with clouds.

C. Group Discussion and Decision making:

The observations recorded in the previous and current charts should be discussed among the farmers by raising questions relating to change in pest and defender population in relation to crop stages, soil condition weather factors such as rainy, cloudy or sunny, etc. The group may evolve a strategy based upon weekly AESA, ETL and corresponding change in P: D ratio and take judicious decision for specific pest management practices.

D. Presentation

A member of each group will now present their analysis in front of all participants. Make sure that a different person will present each week. The facilitator will facilitate a discussion by asking guiding questions. The facilitator also makes sure that all participants (also shy persons or illiterate persons) become actively involved in this process. Formulate a common conclusion. The whole group should support the decision on what field management is required. Make sure that the required activities (based on the decision) will be carried out. Keep the drawing for comparison in the following weeks.

47. Hand Pollination, Harvesting And Curing Of Vanilla Orchid

Vanilla is a tropical orchid requiring warm climate with frequent rains. Cured vanilla beans are used as spice and it is one of the costliest spice in the world next to saffron. Due to the peculiar structure of the flowers, self pollination is not possible. Hence hand pollination is adopted. Hand pollination is a daily task and the flowers bloom only for a day. The best time to pollinate vanilla is after one hour of opening of flowers. The flowers bloom at around 7am in the morning and closes in the afternoon. Very few flowers bloom everyday from each branch, so the pollination lasts for more than a month. Successful fertilization is indicated by the retention of calyx and the stigma even after four days of pollination.

Pollination: A toothpick or a grass stem is used to lift the rostellum or move the flap upward, so the overhanging anther can be pressed against the stigma and self-pollinate the vine. Generally, one flower per raceme opens per day. Growers are careful to pollinate only five or six flowers from each raceme. The first flowers that open per vine should be pollinated, so the beans are similar in age. These agronomic practices facilitate harvest and increases bean quality. The fruits require five to six weeks to develop, but around six months to mature. Over-pollination results in diseases and inferior bean quality.

Harvesting: Post-harvest processing and curing of the vanilla beans is an important part of the vanilla cultivation. To get quality-cured beans, one should have experience with sound technical know-how. Vanilla beans are ready for harvest in six to nine months after pollination. The beans are harvested one by one when they are fully-grown and as they begin to ripe. At this stage, beans change their colour from dark green to light green with yellow tinge. Immature beans produce an inferior product and, if picked too late, the beans start splitting. Bunch or broom harvesting should be avoided. The well-ripened ready beans detach easily from the bunch just by lifting them in reverse direction. Immature beans do not detach easily from the stalk; but, on the other hand, leave behind a bit of the bean in the bunch. Hence, to pick the beans at right stage, the plantation should be visited two or three times a week. The green beans do not possess any aroma. Processing and curing should commence within a week of harvest.

Sorting and Grading: Size and appearance get the primary importance here, since; there is a direct relationship between the aroma (or vanillin content) and these factors. The beans are classified according to their length as follows:

Length of Beans	Grade of Beans
15 cm and >	I
10-15 cm	II
10 cm	III
Splits, cuts and damaged beans	IV

Cleaning: The graded beans are washed with clean water.

Killing: Graded beans are transferred to a bamboo basket and immersed in hot water at a temperature of 70°C for periods as indicated below:

Grade of beans	Period of immersion
I	5 minutes
II	4 minutes
III	2 minutes
IV	1.5 minutes

Sweating: The treated beans are then transferred immediately to a wooden box lined with blanket, for sweating and kept for 36-48 hours. The temperature initially is to be 48-50°C. By then, the beans will attain light brown colour and start imparting aroma.

Sun drying: Later on, the beans are spread in hot sun (from 12 noon to 3 pm) over wooden loft on a clean black blanket. The temperature of the bean, at this time should raise to 50°C. Later on, the bundles are transferred to the sweating box. Sun drying and sweating is continued grade-wise, as follows:

Grade	Period
I	12-14 days
II	7-10 days
III & IV	5-7 days

At the end of this period, the beans lose half of initial weight, turn to a shining dark brown colour and develop wrinkles. Also, their aroma improves.

Slow drying: The next step involves the spreading of the beans in racks kept in well-ventilated room maintained around a temperature of 35°C and relative humidity of 70 per cent. The duration of slow drying is as follows:

Grade	Period
I	20-35 days
II	10-20 days
III	3-10 days
IV	2-8 days

On completion of slow drying, the vanilla beans get heavy longitudinal wrinkles, turn lustrous with brownish black colour and become supple. They offer a soft leathery touch; can be rolled around finger easily and on release, becoming straight. The moisture content at this stage may be around 30-35 per cent.

Conditioning: The dried and classified beans are bundled (150 - 250 gm each), tied with a thread and kept for conditioning inside wooden or metal boxes lined with wax paper for two months. By this time, there is a further loss of three to four per cent moisture with the full development fragrance. Finally, the bundles are wrapped in wax papers and stored in airtight containers. The reduction in weight from green to conditioned beans ranges from 4.5:1 to 6:1, depending on the grade.

On the whole, meticulous care has to be taken during the curing process, as otherwise the quality of the beans may get deteriorated due to fungal, bacterial or other pest damage.

Points to remember

1. To get quality and sustainable yield, organic farming technique is to be adopted.
2. Curing of green beans is to be commenced within a week of harvest.
3. Matured, light green with tinge of yellow coloured beans are to be harvested individually, avoiding broom harvesting.
4. For heat killing, temperature of water should not exceed 65-70^{o}C.
5. Initial sweating is to be for 24 to 48 hours. Extension of this period will initiate rotting.
6. Daily sun drying is to be followed by proper sweating for controlled fermentation.
7. The beans are to be examined everyday during sun drying and slow drying for avoiding infection.
8. Moulds, if noticed, have to be removed from time to time. These beans are kept away from other beans.
9. As in the previous steps, beans are to be checked regularly, during conditioning too; to avoid any infection.

Conclusion: The vanilla cultivation got a fillip about a decade ago. Because of the efforts of the early growers, Indian beans have been rated as the best in the world with high vanillin content. Due to this, all the major international dealers have come to India. Keeping up the quality of the beans by harvesting only mature beans, proper processing and timely curing is very important.

48. Value Addition Of Amla [Code-102]

Amla (*Emblica officinalis*)

Family- Euphorbiaceae

Amla is an important fruit crop grows in tropical and subtropical parts of India, China, Indonesia and the Malay Peninsula. It is rich source of vitamin and tannins. Generally aonla is considered as "Wonder Fruit for Health". It is known by different names like aonla, amalakki, nelli and Indian gooseberry. It is a highly valued among indigenous medicines. The edible tissue of aonla contains about three times more protein and 160 times more vitamin C as compare to apple (Barthakur and Arnold, 1991). The high acceptability of aonla fruits could be due to their high medicinal values and the fact that they are richest source of vitamin C among all other fruits except for Barbados cherry (Asenjo, 1953; and Shankar, 1969). It has an astringent taste and therefore, not popular as a table fruit. However, it shows great potential for processing into various quality products, which can have great demand in national as well as international market.

Importance:
All parts of the plant are used for medicinal purpose. The fresh or dry fruit is used in traditional medicines for the treatment of diarrhea, jaundice and inflammations. The pulp of the fruit is smeared on the head to dispel headache and dizziness. Emblica officinalis leaves and fruit have been used for fever and inflammatory treatments by rural populations in its growing areas. The earlier study have demonstrated potent anti-microbial, anti-oxidant adaptogenic, hepatoprotective, anti-tumour and anti-ulcerogenic activities in the fruits of Emblica officinalis. Leaf extracts have been shown to possess anti-inflammatory activity. Ethanol and aqueous extract of Emblica officinalis has shown significant anti-inflammatory activity.

Aonla Candy - Fruit candies are becoming more and more popular because of high acceptability, minimum volume, higher nutritionally value and longer storage life. These have additional advantage of being least thirst provoking and ready to eat snacks. For the preparation of aonla candy, mature fruit are washed, pricked and dipped in 2 percent salt solution for 24 hours. Then fruits are washed and dipped in 2% alum solution for 24 hours. The fruit are thoroughly washed and blanched in boiling water for 5 minutes and steeped in 50° Brix syrup solution for 24 hours. The next day steeping is done in 60° Brix for 24 hours. Again steeping is done in 70° Brix for 72 hours. Excess syrup is drained. The fruit are dried to 15% moisture content and coated with powdered sugar / pectin. Packaging is done in polythene pouches (400 gauge).

Jam - Aonla fruit pulp (50%) is taken and 67% sugar is added. Herbs like 5% asparagus and 2% ashwagandha extract will increase its medicinal properties. The mixture is cooked and citric acid is added (acidity 1.2%). After judging the end point (68° Brix), it is filled into clean sterilised glass jars, upon setting of jam, lids and jars are closed ensuring an air tight seal.

Sauce - Five kg of sauce containing 50% aonla pulp and 50% tomato pulp with 75g sugar, 10g salt, 60g onion, 6g garlic, 12g ginger, 5g red chillies, 12g hot spices was prepared. Acetic acid and sodium benzoate as preservatives were added at the rate of 1ml and 0.3g / kg of final product, respectively. Finally the sauce was filled in glass bottles and crown corked followed by processing in boiling water for 30 minutes and air-cooled. The product was highly acceptable even after the storage period of more than 9 months.

Flow chart for processing of jam

Ripe firm fruits

▼

Washing

▼

Peeling

▼

Pulping (remove seed and core)

▼

Addition of sugar (add water if necessary)

▼

Boiling (with continuous stirring)

▼

Addition of citric acid

▼

Judging of end-point by further cooking up

◄

to 105ºC or 68-70 per cent TSS or by sheet test

▼

Filling hot into sterilized bottles

▼

Cooling

◄

Waxing

▼

Capping

◄

Storage (at ambient temperature)

Aonla Chutney: Aonla chutney is generally hot, sweet, smooth spicy, mellow flavoured and appetizing. Sometimes raising and dry fruits are also added to increase its taste and nutritional value.

Flow chart for amla chutney

Fruit

▼

Washing

▼

Boiling for 25-30 minutes

▼

Separation into segments and removal of seed

▼

Making into fine pulp

▼

Addition of one half its weights of water, sugar and salt and cooking gently

▼

Keeping all ingredients (except vinegar) in cloth bag, tied loosely, putting intomixture and cooking on low flame

During cooking spices bag pressed occasionally
Cooking to consistency of jam (upto105ºC) with occasional stirring

▼

Removal of spice bag after squeezing

Addition of vinegar

▼

Cooking for 2-5 minutes

▼

Filling hot into clean and sterilized bottles

▼

Sealing (airtight)

▼

Storage at ambient temperature
(In cool and dry place)

49. Value Addition Of Cassava [Code- 18]

Cassava is a woody perennial and branched shrub that can grow up to 5 metre in height. It is a cheap and major source of calories for over 40% of the population. In India it is cultivated in the southern state and the northeast. The fresh tuber has a very short shelf life of about three days, therefore value addition is often done to the crop through processing into many types of product for different utilization and to prevent post- harvest loss. Cassava processing which adds value to the crop increases income from the product and also provides employment. The root is not the only part of the plant that can be put to good use but leaves can be cooked as a vegetable and for raising silkworms. The green part of the upper stem is fed to cattle and buffaloes, and the leaf-blades to pigs and chicken.

Some value added product derived from Cassava are:

A. Cassava Flour:

Procedure to make:

1. Cut into thin pieces the peeled root crop.
2. Place in a basin of water.
3. Spread the thin pieces on a tray to dry under the sun or in a solar dryer.
4. Grind the dried cassava and sieve fine.
5. Seal in a container with a tight cover.

B. Cassava Chips:

Procedure to make:

1. Wash cassava well, peel and slice very thinly.
2. Soak in 2% salt water with flavouring.
3. Spread on a tray and steam for 5 minutes.
4. Dry in a solar drier or sun at 60˚C for 5 hour.
5. Seal in plastic bags until ready for frying before serving.

C. Cassava Pasta:

Procedure to make:

1. Pour the cassava flour add eggs and mix using a fork.
2. Mixed the egg with flour for 15 minutes by hand until it is compact, smooth and elastic.
3. Form it into a ball and leave it to rest for 1 hour at room temperature.
4. 4. Then divide the ball into three equal sized pieces. Roll each pieces of Pasta through the rollers at the maximum thickness setting.
5. Use the pasta dryer or rest the pasta on a cloth for at least 10 minutes, then put it into bags.

D. Cassava Butter Cake

Procedure to make:

1. Sieve the cassava flour and baking powder together
2. Cream margarine in a big bowl until fine.
3. Gradually add sugar with constant stirring.
4. Add alternately and little by little, beaten egg yolk, cassava flour, munggo flour,
5. baking powder and milk.

6. Mix well, stirring in one direction only.
7. Beat the egg whites until flubby and stiff, and;
8. Add little by little to the mixture.
9. Put mixture in pan and cook in oven at 307˚C for 25-30 minutes.
10. Remove from oven and cool serve.

E Cassava Shrimp Stick

Procedure:

1. Wash the cassava, peel and grate.
2. Remove excess juice.
3. Mix together in a bowl all the dry ingredients.
4. Add cassava and 2tbsp oil. Mix well.
5. With the aid of 2 knives, cut the dough fine into sizes like mongo seeds.
6. Add water and knead well.
7. Spread the flour on the board and flatten the dough with the aid of a rolling pin. If necessary, add more flour to facilitate dough flattening.
8. Cut up the flattened dough into thin sizes shape into rolls similar to cigarette sticks.
9. Arrange them in a baking pan and cook in oven.
10. Remove the baking pan and cool.
11. Remove the “sticks” from the pan with the aid of a knife.
12. Seal in a plastic bag and label or serve.

F. Production of Cassava Starch

1. Cassava starch is produced from unfermented cassava paste, the processes involve
2. Mix the cassava paste in a vat of water, at a ratio of 5 litres of water to 1 Kg of paste.
3. Sift the mixture and collect the starch milk in a basin. Allow the starch to settle for 1 hour.
4. Collect the paste that has been deposited at the bottom and leave it to dry in the sun. This extracts the starch.
5. Grind the starch and sift the powder, then package it into bags.

50. On-Farm Production Technology For Mass Production Of *Trichoderma* Spp.

Among the several biocontrol agents, *Trichoderma* spp. are known to occur in all agroecosystems, commonly associated with root, soil and plant debris / plant organic matter. Since 1930s, *Trichoderma* species are recognized as biological agents to protect crops against several soil and air borne plant pathogents belonging to the genus *Phytophthora, Rhizoctonia, Botrytis, Alternaria, Berticillium, Colletotrichum, Fusarium, Sclerotium, Pythium, Scalerotinia, Macrophomina* etc. *Trichoderma* spp. act through rhizophere competition, antibiosis, mycoparasitism against soil borne and foliar phytopathogenic fungi, bacteria, nematodes and sometimes their efficacy on soil borne fungal disease is higher than fungicides. *Trichoderma* spp. also stimulate plant growth, enhance germination, plant survival, growth of roots & shoots.

Trichoderma spp. can be produced at the farm level for which the requirements include an exclusive room, gas stove, 10-20 litre pressure cooker, wooden inoculation champer, plastic trays, autoclavable bags, PVC pipes, candle / spirit lamp, inoculation loop / spatula / glass rods, non-absorbent cotton, rubber bands, mixer grinder, sealing machine etc. In addition to the mother culture of the *Trichoderma* spp. The media in semi-cold state fermentation is needed. Semi solid media could be prepared by using maize, sorghum, rice, etc. in the autoclavable bags. For mass multiplication of *Trichoderma* spp. the following steps should be followed sequentially as noted below:

1. Take about 150-200 gm of maize grains in autoclavable bags (Polypropylene plastics) and add lesser amount (50-100ml) of tap water / wet the grains in a basin.
2. After filling the bags, keep a 1.5'' inches PVC pipe at the top of the cover and tied it with a rubber band.
3. Close PVC pipe mouth using cotton plug.
4. Boil the grains in a 10-20 litre pressure cooker with water inside it for a period of 30-40 minutes.
5. The grains are cooled at room temperature sterilization.
6. Transfer the bags into a wooden inoculation chamber. Spirit lamp / candle should be flamed after closing the inoculation chamber for about 5 to 10 minutes.
7. Inoculate with 1-2 bits or *Trichoderma* mother culture in each bag inside the chamber with the help of inoculation loop / spatula. Shake the bags properly for mixing the fungal culture all over the grains.
8. Cover the cotton plug with brown paper / newspaper and label it.
9. Keep the inoculated bags at the room temperature (25-30 ^{o}C).
10. Observe the inoculated bags if there is mycelia growth, do not disturb the inoculated bag. If mycelia growth is not observe, shake the inoculated bag.
11. Once *Trichoderma* sporulation (green colour) takes place shake the bags every alternate day for about 5 to 7 days in order to spread and allow the *Trichoderma* growth and further sporulation.
12. Transfer the grains with fully grown *Trichoderma* mycelia & sporulation into cleaned plastic trays and cover it with blotter / newspaper. Keep these plastic trays for further sporulation and drying for about 3-4 days at room temperature. Mix the transferred *Trichoderma*

colonized grains once in every day for up to 3-4 days with the help of spatula for enhancing sporulation and drying.

13. The *Trichoderma* will be ready for use as soil application or the grounded fine powder for seed treatment and or foliar application.

From 1 kg sorghum / maize grains approximately 500 gm dried biomass of *Trichoderma* including grains can be produced, which could be utilized directly for soil application for one hectare after mixing in 100 kg of well decomposed compost of Farm Yard Manure (FYM). The dry biomass powder can be utilized for seed treatment @ 5-10 g / kg seed.

51. Litchi Value Addition (Code No: 41)

Introduction: -

The Litchi (Litchi chinensis sonn) is an important subtropical evergreen fruit crop belonging to the family Sapindaceae. Known for its embattled and spiked tough skin with a luscious, sweet pulp inside. Litchi is a summer time favourite in India. It is highly specific to climatic requirement and preservation from insect pests for its establishment, plant growth and fruiting. The major litchi harvesting areas include Bihar, Uttarakhand, West Bengal and Assam. North Bihar is one of the highest litchi producing area.

Economic Importance: -

The fruit is also rich in Vitamin B1, Riboflavin & Vitamin C apart from proteins (0.7%), fats (0.3%), carbohydrates (9.4%), minerals (0.7%), fibrous matter (2.25%), calcium (0.21%), phosphorus (0.31%), iron (0.03%) and carotene. Litchi makes an excellent canned fruit. A highly flavored squash is also prepared from the litchi fruits, which is used during summers. Various other products such as pickles, preserves and wine are also made from litchi in China. Dried litchi commonly called Litchi-nut is very popular among the Chinese.

Post-harvest management: -

Litchi is non-climacteric fruit that possesses poor shelf life and therefore needs specific treatment before packing and transportation for long distance market. For local markets, the fruits should be collected at the ripened stage, while for distant market, the fruits should be harvested when they have started turning reddish. After harvesting, the fruits should be kept in cool, dry and properly ventilated rooms to facilitate the ripening process under high atmospheric temperature. If exposed to sun even for a few hours the quality deteriorates markedly.

Grading

Grading is done according to the size of the fruits. The damaged, sun-burnt and cracked fruits are sorted out before packing.

Storage

The fruits cannot be stored at room temperature for more than a few days. It loses its bright red colour and turns brown within 2 – 3 days after harvesting. Mature litchi fruits can be stored for a period of 8 to 12 weeks at the temp. of 1.6 to 1.7^{0}C and relative humidity ranging between 85 to 90%.

Packing

The fruits are graded and packed in shallow baskets or crates lined with leaves of litchi, soft dry grass or banana leaves.

Transportation

The fruit along with twigs is packed and transported by truck to the wholesalers and retailers of the nearest towns. During transit, care should be taken to avoid crushing of fruits and damage of the skin. Litchi being a highly perishable fruit, its marketing should be done as early as possible.

Value added products of litchi:

1. Litchi pulp

- Homogenized juice of litchi fruit pulp

- Litchi pulp is used in preparation of beverages like squash, nectar, RTS, cordial etc.
- Permitted class-II preservative added
- Store in air-tight containers of convenient size
- Storage life up to one year under refrigerated conditions

2. Litchi squash
    - Contains litchi pulp (25% v / v), TSS (40ºB), acidity (0.8%), permitted class-II preservative and stabilizer
    - Diluted before consumption
    - Best before 4 months
    - Keep in refrigerator after breaking seal and consume within 2-3 days
3. Litchi RTS Ready-to-Serve fruit beverage
    - Contains litchi pulp (10% v / v), TSS (10ºB), acidity (0.3%), and stabilizer
    - Store under refrigerated conditions
    - Storage up to 4 months
4. Canned Litchi
    - Litchi aril preserved in sugar syrup inside air-tight glass bottle
    - No chemical preservative added
    - Best before 1 year
5. Dehydrated litchi pulp
    - Prepared through osmo-mechanical dehydration
    - Packed in air-tight packaging
    - Stored in cool and dry conditions
    - Storage life > 1 year under refrigerated conditions
6. Litchi nut
    - Whole litchi fruit is dried
    - Product is packed in air-tight packaging
    - Storage life > 1 year
7. Litchi wine
    - Alcoholic product prepared through anaerobic fermentation of litchi fruit pulp
    - Contains 10-12% alcohol
    - Product retains flavor of litchi

52. Sweet Potato (Code No: 73)

Introduction:

Sweet potato is cultivated for its sweet root tubers. It is originated from the native of America. The scientific name for sweet potato is *Ipomoea batata* which belongs to a family Convolvulaceae. It is one of the important root and tuber crop in India as well as in Meghalaya due to its rich source of starch. It is popularly known as **Sakarkand** in all over India and **Meetha aloo** in north eastern region where as in Garo hills it is called **Tamilang**. It contains high beta-carotene as well as good source of carbohydrate, ascorbic acid and vitamin B complex. It is mainly used for human food after boiling or steaming, baking or frying and also as animal feed.

Season of growing/Planting season:

Sweet potato is normally grown in rainy season and the best time for planting in Meghalaya is last week of May to first week of June. It requires well drained fertile soil rich in humus.

Varieties:

High yielding varieties suitable for cultivation in Meghalaya are Sonipat-2, Sree Bhadra, H-42, H-620 and S-104.

Cropping system:

Sweet potato is mainly grown in cereal based cropping system because of its ability to use residual fertility and moisture more efficiently. It can also be intercropped with other crops such as coconut, arecanut and banana for attaining maximum productivity and profitability.

Land Preparation:

The land should be ploughed to depth of 15cm to 20cm and brought to fine tilth. The raised beds of 30cm height are prepared and planting is done in ridges and furrows. Planting in ridges is the best method for getting higher yield.

Seed treatment:

Before planting in the main field, nursery is raised by selecting healthy and disease free tubers. The vines are ready for planting in the main field 45 days after sowing.

Seed rate:

About 40 thousand to 50 thousand vine cuttings can be accommodated in one hectare of land.

Spacing:

Vine cutting of 20-25cm length are planted in ridges at a distance of 30-40cm vines.

Water management:

After planting irrigation is given once in 2days for period of 10 days and thereafter irrigation is given once in 7-10days interval. Irrigation must be stopped before 3 weeks of harvesting, but before 2 days of harvesting one irrigation is necessary.

Weed Management:

Mulching can be an efficient practice of managing weeds and also narrow plant spacing could be used to improve weed management in sweet-potato.

Intercultural operation:

The first intercultural operation at 30 days after planting along with weeding and earthing-up improves the soil the physical condition of soil. The second intercultural operation and earthing-up should be done 45-60days after planting followed by turning of vines. The weed are problem only during first two months of growth. After that vigorous growth of vine caused rapid and effective coverage of ground surface.

Integrated Nutrient Management:

Apply 5 tonnes of farmyard manure/ha at the time of field preparation. Using leguminous crops as green manure are also advisable to apply at least one month before the plant are set out.

Integrated pest management in Sweet potato:

Sweet potato weevil: Sweet potato weevil is a most serious pest of this crop. The pale yellow grub of this pest bores into the vines. The control measures for this pest are use of uninfested vine tips as planting material, crop rotation, timely planting and prompt harvesting to avoid a dry period and use of sex pheromone traps.

Sweet potato sphinx: It is a serious leaf eating caterpillar of sweet potato. Hand picking and destroying the caterpillar is the best method for destroying this pest.

Harvesting:

Harvesting is done by digging out tuber with pick-axe when leaves turn yellow in colour. After harvesting tubers are kept under high temperature and high humidity condition for 4-7 days for toughness of outer skin and to minimise the damages.