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Organic Fruit Production

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Introduction

Organic farming involves an approach to food production. It seeks to create a sustainable agricultural system that relies first and foremost on ecological interactions and biological processes rather than chemical inputs. The aim of Organic farming is to produce optimum yields with minimum harm to the surrounding environment.

Most organic production standards clearly advocate the adoption of sustainable on-farm resource based management approach and advice to avoid the use of synthetic fertilizers and pesticides. But unfortunately it has led to the wrong assumption that no use of synthetic inputs is organic farming. Organic agriculture is not a system of neglect. It negates the need for synthetic pesticides and fertilizers by improving soil fertility by using composts, natural minerals, and cover crops and by recycling organic materials. Cultural and ecological management systems are used as the primary tools for control of pests, weeds and diseases, with limited use of natural biocides of mineral, plant and biological origin as last resort.

In real terms organic farming aims at doing everything to achieve higher productivity in tandem with nature with very high input of knowledge, efficient resource cycling, judicious use of water and harvesting the best benefits of all ecological and biological processes.

Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestocks feed additives. To the maximum extent feasible, organic farming systems rely on crop rotation, crop residues, animal manures, legumes, green manures, off farm organic wastes and aspects of biological pest control to maintain soil productivity and tilth to supply nutrients and to control insects, weeds and other pests (Lampkin, 1990).

The Need for Organic Cultivation of Fruits

Growing awareness among consumers for safe

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and healthy, chemical residue free food, especially, the items required for raw consumption such as fruits and salad vegetables has resulted into demand for organically grown residue free fruits and vegetables. Among various commodities fruits, vegetables and dairy products are the most preferred organic commodities. Keeping in view of the growing demand nationally and internationally, central and state governments have also launched various support schemes for facilitating capacity building, technology transfer, supporting production of organic inputs, both on-farm and off-farm and ensuring credible quality assurance system through third party certification for export and participatory guarantee system for domestic market.

General Principles for Establishing Organic Orchard

Although fundamental steps of organic orchard management are not very different from conventional system, but some issues need special attention, as due to prohibition on use of chemicals there may be some limitations in respect of soil fertility maintenance, weed control and disease management. For setting up of new plantations in depth assessment of physical and environmental factors is essential to determine whether the particular crop can be grown easily, marginally, or not at all. Fruit trees, like any other crops, although respond to good soil with vigour and productivity but can also be grown successfully with optimum commercial yield even on hill sides, rocky soils, and other sites not suitable for other crops requiring tillage.

I. Choice of Fruit Crop and Variety Selection

As fruit trees are perennial and represent a considerable investment of both time and money, it is important to start by planting orchard with the optimum varieties for a particular location and intended markets. While establishment of an organic fruit orchard, clearly, the first option comes in mind is which species should have to plant. Careful consideration of environmental conditions, as well as the locations of markets and suppliers, is of tantamount importance. For example, organic peach production under humid climatic condition is greatly complicated due the presence of the plum curculio (Conotrachelus nenuphar) and by greater disease pressure than in the drier climates. In general, small fruits (blueberries, blackberries, raspberries) are easier to produce organically than tree fruits in almost all locations.

The availability of production supplies and markets in a particular region can be a critical factor in crop selection. The following points should be consider while selecting fruit crop and variety,

1. All seeds and plant material should be certified organic.
2. Species and varieties cultivated should, as far as possible, be adapted to the soil and climatic conditions and be resistant to pests diseases.
3. A moratorium on all transgenic food and agricultural applications should be imposed.
4. In the choice of varieties genetic diversity should be taken into consideration.

Once the crop species has been decided, the next question comes in the mind about the proper selection of variety and rootstock of that particular crop. Following points must be considered by the growers during selection of a particular variety -

1. **Harvest season:** Early, mid, or late season, or a combination of these to achieve a more continuous supply or to ensure a crop during early or late marketing windows.
2. **Adaptability to the region:** Cold hardiness, salinity tolerance, temperature ranges for optimal growth, requirements for soil fertility or pH.
3. **Water requirements:** Need for irrigation or protection from waterlogging
4. **Stature:** Dwarf, semi-dwarf, or standard
5. **Marketability:** Colour, flavor, nutritional value, storage requirements, shipability, uniformity, shelf life - any characteristics that define quality for customer
6. Chill requirements for fruit set
7. Proximity to appropriate markets

Growers should select desired characteristics, especially in grafted trees, with a combination of varieties of rootstock and fruiting wood.

Seed/ Planting material Treatment

In organic fruit production, protection measures are used only in the case of problematic situations. Use of disease free seed stock and resistant varieties is the best option. There is no standard formulation or treatment methodology, available as on today, but farmers use different methods for seed of guava, rayan, ber, citrus, sapota, *etc*. Few of such innovative seed treating formulations are as follows:

- Hot water treatment at 53^0C for 20-30 min.
- Cow urine or cow urine-termite mound soil paste
- Beejamrut
- Asphoetida 250gm in one lit. of water for 10 kg seed
- Turmeric rhizome powder mixed with cow urine
- Panchgavya extract
- Dashparni extract

- Trichoderma viride (4gm/kg seed) or Pseudomonas fluorscens (10gm/kg seed)
- Biofertilizers (Rhizobium/ Azotobacter +PSB)

II. Site Preparation

To grow organic fruit successfully, it is very important to maximise the local environmental factors in favour of particular fruit crops. It can be done by selecting a particular crop grown in the locality followed by the selection of the most appropriate site. After site selection, important considerations include alleviating soil compaction, enhancing fertility, adjusting soil pH, and managing weeds, pests, and diseases. Before establishing an orchard, it is important to adjust the soil pH. In case if pH correction is required then the same can be done through use of lime or dolomite for acidic soils and by use of gypsum or sulphur for alkaline soils. Most fruit plants perform best around pH 6.5, although they can tolerate a pH range between 5.5 and 7.2. Generally, fruit crops do not require highly fertile soils for good production, though this varies with the species. Highly fertile soils, rich in nitrogen, can promote too much vegetative growth at the expense of fruiting in trees such as apples. Pre-plant soil improvement for organic fruit planting usually involves some combination of cover and legume cropping and applications of compost, natural minerals, or other organic manures.

Crop Rotations

Crop rotation involves planting different crop species at different times and locations on the same field. In an organic orchard, crop rotation does not mean changing the economic crop itself, but diversifying the vegetation that grows around the fruit crop. Rotating crops improve the tilth or structure of the soil and increase in soil microbial activity which may increase nutrient availability and including phosphorus. Yields are usually 10 to 15% higher with the practice of crop rotation than monoculture (Frick and Johnson, 2006). Using alley cropping, intercropping and hedgerows to enhance biological diversity is also an ideal option.

Orchard Floor Management/Cover Crops

The orchard floor, the tree rows and alleyways can be managed in a variety of ways, using tillage or mowing with cover crops, grazing, or mulching. An orchard providing full ground cover with cover crops/ mulches etc ensures best protection against erosion. Clean cultivation (keeping orchard floor free from weeds/ crops/ mulches) is prone to erosion, gradual depletion of organic matter, increased soil compaction, and reduced water infiltration.

Green manuring

Green manuring has been known for its improvement on the soil fertility. The benefits of green manuring are multifold. It increases soil organic matter, concentration of nutrients near the soil surface in available form especially the available nitrogen, and reduces N losses through leaching and soil erosion. The soil aggregation due to increased organic matter in soil improves the soil physical properties (Mc Rae and Mehuys, 1988). Green manuring is useful in minimizing the ill effects of intensive agriculture particularly on natural resources. Plant nutrients are provided in a better form and over a longer period for the crops grown after green manuring. However, the choice of green manuring crops has to be made in relation to soil, climate and time available to raise the green manure crop and the facilities for irrigation. Leguminous green manuring crop fixes the atmospheric nitrogen in the soil in available form, improves the soil health, physical structure, prevents leaching and conserve more soil moisture. Green manuring being a low cost practice, is an alternate way to improve soil fertility status. It has received a new impetus in recent years with an urgent need for increased food production in the country (Virdi et al., 2005).

Classification of green manures

Legumes		Non -Legumes	
Green manure	**Green leaf manure**	**Green manure**	**Green leaf manure**
Daincha	Gliricidia	Sunflower	Calotropis
Sunhemp	Cassia	Buck wheat	Adathoda
Kolinji	Pongamia glabra		Thespesia

Common shrubs and trees used as green leaf manures

Shrubs	Trees	Green Leaf Manures
Cassia auriculata	Thespesia populnea	Leucaena leucocephala
Derris indica	Neem	Calotropis gigantea
Ipomoea cornea	Glyricidia	Delonix regia
Jatropha	Cassia tora	Cassia Occidental
Tephrosia candida	Vitex negundu	Hibiscus viscosa

Nutrient content of green manure crops

Plant	Scientific name	Nutrient content (%) on air dry basis		
		N	P_2O_5	K
Sunhemp	*Crotalaria juncea*	2.30	0.50	1.80
Dhaincha	*Sesbania aculeata*	3.50	0.60	1.20
Sesbania	*Sesbania speciosa*	2.71	0.53	2.21

Nutrient content of green leaf manure				
Plant	**Scientific name**	**Nutrient content (%) on air dry basis**		
		N	**P_2O_5**	**K**
Gliricidia	*Gliricidia sepium*	2.76	0.28	4.60
Pongania	*Pongamia glabra*	3.31	0.44	2.39
Neem	*Azadirachta indica*	2.83	0.28	0.35
Gulmohur	*Delonix regia*	2.76	0.46	0.50
Peltophorum	*Peltophorum ferrugenum*	2.63	0.37	0.50

III. Nutrient Management

In organic management as majority of the nitrogen comes from organic sources, accompanied with other minerals such as P, K and micronutrients generally, nitrogen is considered as the index element for calculation. Organic materials with a C:N ratio of less than 20:1 (such as FYM, enriched compost vermicompost or concentrated manures from oil cakes etc), nitrogen is release fairly rapidly into the soil, from which it can be taken up by plants. Organic materials with a C:N ratio in the range of 25:1 to 30:l release N slowly while decomposing, whereas materials with C:N ratios above 35:I (such as crop residue tree leaves, or wheat/ rice straw) can immobilize soil N for several weeks or months. Therefore we need to ensure that only the material having C:N ratio below 25 be incorporated with the soil and the material having C:N ratio above 25 to 35 is used as surface mulch. In cases where tree leaves, forest litter or crop residue is to be used as surface mulch having wider C:N ratio then it needs to be mixed with either legume residue or be sprayed with dung-urine based liquid manures (such as *Jivamrit* or *Amrit Pani*) for faster decomposition.

Based upon long term studies it is understood that, the percent or total nitrogen that is available during the current season can be estimated at 70% for concentrated manures (having C:N ratio below 10: 1), 50% for manure and cover crops (having C:N ratio below 25), and just 10-25% for other material having C:N ratio above 30: 1. Remaining N, gets incorporated into the soil organic N pool, which is a vital long-term source of N. Some manure-N may leach or volatilize, and some may enter the organic N pool, depending on the C:N ratio of the manure-mulch mix. While the "available" portion of compost, manure, and mulch N fulfills the needs of the current crop, the "unavailable" portion of manure, compost and mulch N, goes toward replenishing soil

organic N and helps to manage the soil's aeration and water holding capacity.

On Farm Production of Some Innovative Organic Inputs

Biodynamic (BD) preparations and compost, NADEP compost and vermicompost can be produced with decomposition of locally available organic wastes and cow dung. BD-500 i.e. cow dung duly incubated in cow horn is helpful in improving biological activity of soil and BD-501 i.e. silica in horn mediates photosynthesis and provides defence against fungal infection. BD- liquid pesticides prepared from cow dung, cow urine and locally available herbs such as neem, *Calotropis*, *Lantana*, custard apple *etc.* along with BD-sets provides excellent plant protection solution. *Jivamrit, Panchagavya* and *Amrit Pani* are effective plant growth promoters in nurseries and fields.

Some important formulations for soil enrichment

Preparation of liquid manures

Many variants of liquid manures are being used by farmers of different states. Few important and widely used formulations are given below:

Sanjivak **–** Mix 100 kg cow dung, 100 lit cow urine and 500 gm jaggary in 300 lit of water in a 500-lit closed drum. Ferment for 10 days. Dilute with 20 times water and sprinkle in one acre either as soil spray or along with irrigation water.

Jivamrut **–** Mix cow dung 10 kg, cow urine 10 lit, Jaggary 2 kg, any pulse grain flour 2 kg and Live forest soil 1 kg in 200 lit water. Ferment for 5 to 7 days. Stir the solution regularly three times a day. Use in one acre with irrigation water.

Amritpani - Mix 10 kg cow dung with 500 gm honey and mix thoroughly to form a creamy paste. Add 250 gm of cow desi ghee and mix at high speed. Dilute with 200 lit water. Sprinkle this suspension in one acre over soil or with irrigation water. After 30 days apply second dose in between the row of plants or through irrigation water.

Panchgavya **–** Mix fresh cow dung 5 kg, cow urine 3 lit, cow milk 2 lit, curd 2 lit, cow butter oil 1 kg and ferment for 7 days with twice stirring per day. Dilute 3 lit of Panchgavya in 100 lit water and spray over soil. 20 lit panchgavya is needed per acre for soil application along with irrigation water.

Enriched *Panchgavya* (or *Dashagavya*) – Ingredients - cow dung 5 kg, cow urine 3 lit, cow milk 2 lit, curd 2 lit, cow deshi ghee 1 kg, sugarcane juice 3 lit, tender coconut water 3 lit, banana paste of 12 fruits and toddy or grape juice 2 lit. Mix cow dung and ghee in a container and ferment for 3 days with intermittent stirring. Add rest of the ingredients on the fourth day and ferment for

15 days with stirring twice daily. The formulation will be ready in 18 days. Sugarcane juice can be replaced with 500 g jaggery in 3 lits water. In case of non-availability of toddy or grape juice 100g yeast powder mixed with 100 g jaggery and 2 lit of warm water can also be used. For foliar spray 3-4 lit panchgavya is diluted with 100lit water. For soil application 50 lit panchagavya is sufficient for one ha. It can also be used for seed treatment.

Biofertilizers

In nature, there are a number of useful soil micro organisms which can help plants to absorb nutrients. Their utility can be enhanced with human intervention by selecting efficient organisms, culturing them and adding them to soils directly or through seeds. The cultured micro organisms packed in some carrier material for easy application in the field are called bio-fertilisers. Thus, the critical input in Biofertilisers is the micro organisms.

Types of Biofertilizers

Based on type of microorganism, the bio-fertilizer can also be classified as follows:

- **Bacterial Biofertilizers**: e.g. Rhizobium, Azospirilium, Azotobacter, Phosphobacteria.
- **Fungal Biofertilizers**: e.g. Mycorhiza
- **Algal Biofertilizers**: e.g. Blue Green Algae (BGA) and Azolla.
- **Actinimycetes Biofertilizer**: e.g. Frankia.

Bio-fertilizer are mostly cultured and multiplied it the laboratory. However, blue green algae and azolla can be mass-multiplied in the field.

Characteristics Features of common Biofertilizers

- ***Rhizobium*** : *Rhizobium* is relatively more effective and widely used biofertilizer. *Rhizobium*, in association with legumes, fixes atmospheric N. The legumes and their symbiotic association with the *Rhizobium* bacterium result in the formation of root nodules that fix atmospheric N. Successful nodulation of leguminous crop by *Rhizobium* largely depends on the availability of a compatible stain for a particular legume. *Rhizobium* population in the soil is dependent on the presence of legumes crops in field. In the absence of legumes the population of *Rhizobium* in the soil diminishes.
- ***Azospirillum*** : *Azospirillum* is known to have a close associative symbiosis with the higher plant system. These bacteria have association with cereals like; sorghum, maize, pearl millet, finger millet, foxtail millet and other minor millets and also fodder grasses.

- ***Azotobacter*** : It is a common soil bacterium. *A. chrococcum* is present widely in Indian soil. Soil organic matter is the important factor that decides the growth of this bacteria.
- **Blue Green Algae (BGA)** : Blue green algae are referred to as rice organisms because of their abundance in the rice field. Many species belonging to the genera, Tolypothrix, Nostic, Schizothrix, Calothrix, Anoboenosois and Plectonema are abundant in tropical conditions. Most of the nitrogen fixation BGA are filamenters, consisting of chain of vegetative cell including specialized cells called heterocyst which function as a micronodule for synthesis and N fixing machinery.

Method of application:

Biofertilizers can be applied to different crops and plants by three different ways.

1. **Seed treatment**: 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. For acidic and alkaline soils it is always advisable to use 1 kg of slacked lime or gypsum powder respectively for coating the wet biofertilizer treated seeds.
2. **Seedling root dip treatment:** 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. In case of paddy make a sufficient size bed (2mt x 1.5mt x 0.15mt) in the field, fill it with 5 cm of water and suspend 2 kg each of Azospirillum and PSB and mix thoroughly. Now dip the roots of seedlings in this bed for 8-12 hours (overnight) and then transplant.
3. **Soil treatment:** For soil treatment depending upon the total number of plants per acre 2-4 kg of *Azotobacter/Azospirillum* and 2-4 kg of PSB are required for one acre. Mix two types of biofertilizer in 2-4 liters of water separately and sprinkle this suspension on two separate heaps of 50-100 kg of compost. Mix the two heaps separately and leave for incubation overnight. After 12 hours, mix the two heaps together. For acidic soils mix 25 kg lime with this mixture.

In plantation crops apply this mixture at the root zones by dibbling. In some field crops the mixture is broadcast evenly in the moist field and mixed with soil just before sowing. In sugarcane the biofertilizer manure is to be applied in furrows near the root zone, after 30-40 days of planting and covered with soil. In potato it is to be applied after 20 days of planting or at the time of earthing-up operations. In case of sugarcane and potato, if setts/tubers are not treated with plant protection chemicals then biofertilizer compost mixture can be applied in furrows immediately before planting.

Preparation of Beejamruta – Put 5 kg fresh cow dung in a cloth bag and suspend in a container filled with water to extract the soluble ingredients of dung. Suspend 50 g lime in 1 lit water separately. After 12 – 16 hours squeeze the bag to collect extract and add 5 lit cow urine, 50 gm virgin forest soil, lime water and 20 lit water. Incubate for 8-12 hours. Filter the contents. The filtrate is used for seed treatment.

IV. Pest management

As in organic farming management use of synthetic chemicals are prohibited, the pest management is done by: (i) cultural or agronomic (ii) mechanical (iii) biological or by (iv) organically acceptable botanical extract or some chemicals such as copper sulphate and soft soap etc.

a. Cultural alternative - Use of disease free seed or stock and resistant varieties are best preventive practice in organic pest management. Maintenance of biodiversity, effective crop rotation, multiple cropping, habitat manipulation and use of trap crops are also effective practices which can keep the population of pests below economical threshold limit (ETL).

b. Mechanical alternative -

1. **Removal of affected plants or parts:** The virus affected diseased plants should be removed from the field; it prevents the transmission of disease to other plants.
2. **Collection & destruction of egg masses and larvae:** Keep surveillance of the crop for pest monitoring and during survey collect the egg masses and larvae from the field and destroy them *i.e.* stem bore, rhinoceros beetles lemon butter fly, *etc*. This practice helps in minimizing the pest load.
3. **Light traps:** Among the most widely used constructed traps are kerosene lamp traps or light traps. Ultraviolet lamps are much more effective than ordinary electric bulbs. These traps should be used at appropriate time,

depending upon the life cycle of the insects. The best time is immediately after the emergence of moths, before they lay the eggs. In these traps the light source is kept over a shallow wide bowl of water added with few spoonfuls of oil or kerosene. Moths that attract towards light fall in this bowl and will not be able to fly. From there they are collected and destroyed.

4. **Pheromone traps:** Sex pheromones are synthetic chemicals that are basically used to attract and trap insect pests so as to reduce the insect population. Since sex pheromones are not sprayed directly on to the crop, there is no pollution problem. This trap is widely used for mango fruit fly.
5. **Use of sticky, coloured plates and other physical traps:** Different species of insects are attracted by different colours. The results indicated that yellow plastic plates coated with grease or any sticky substance and insecticide were effective in controlling leaf miner. This method avoids environmental pollution since the insecticide is not sprayed directly onto the crop. Different colours may attract different insects. Appropriate colours need to be identified for the purpose.
6. **Physical barriers:** The flat snail (*Bradybaena similaris*) is widely distributed in Taiwan, Mainland China, Japan and India. Recently, a method has been developed for controlling the snail by the use of disposable plastic soda bottles made into traps. These prevent the snails from climbing up onto the grapevine. The traps are made by cutting off both ends of the bottle and splitting one side of the body longitudinally to allow it to be sleeved around the stem of the grapevine. The bottles are then stapled firmly around the stem at a height of 1 m above the ground. Since the bottles are tightly fixed around the grape stem, the snails cannot pass through the neck to infest the vines. Unable to descend, all the snails are trapped in the bottle and soon die of starvation. These traps give a control rate of more than 94.8%. This is a very cheap and effective method of controlling flat snail, and there is no threat to the environment. It can thus be widely recommended to grape farmers.

Baggingfruits: Bagging prevents insect pests, especially fruit flies damaging the fruits. The bag provides physical protection from mechanical injuries (scars and scratches) and

prevents egg laying activities of female flies, latex burns and fungal spots on the fruits.

Although bagging is not widely practiced due to involved costs and difficulties in bagging so many fruits, but it is widely practiced in banana, guava, mango, pomegranate world over and is also economical. Wherever possible it can be used and gives reliable estimate of projected harvest.

c. Biological alternative - Use of pest predators and pathogens has also proved to be effective method of keeping pest problem below ETL. Inundative release of Trichogramma sp. @ 40,000 to 50,000 eggs per hectare, Chelonus blackburni @15,000 to 20, 000 per hectare, Apanteles sp.@15,000 to 20,000 per ha and Chrysoperla sp.@ 5,000 per ha., after 15 days of sowing & others parasites & predators after 30 days of sowing, can also effectively control pest problem in organic farming .

Use of Biopesticides - Trichoderma viride or T. harazianum or Pseudomonas fluorescence formulation @ 4gm/kg seed either alone or in combination, manage most of the seed borne & soil borne diseases. There are other formulations viz. Beauvaria bassiana, Metarizium anisopliae, Numeria rileyi, Verticillium sp, which are available in the market and can manage their specific host pest. Bacillus thurengensis stenebrionis and B. thurengensis sandigo are effective against coleopterans as well as some other insect species. Bt. has been used in the management of diamond back moth on crucifers and vegetables @ 0.5-1.0 kg. formulation per ha.

Viral biopesticides of baculovirus group viz. granulosis viruses (GV) and nuclear polyhedrosis viruses provided a great scope in plant protection field. Spray of Nuclear Polyhedrosis Viruses (NPV) of Helicoverpa armigera (H) or Spodoptera litura (S) @ 250 larval equivalents are very effective tools to manage the Helicoverpa sp. or Spodoptera sp. respectively.

Botanical pesticides

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

Neem (Azadirachta indica) – Neem has been found to be effective in the management of approximately 200 insects, pests and nematodes. Neem is very effective against grasshoppers, leaf hoppers, plant hoppers, aphids, jassids, and moth caterpillars. Neem extracts, are also very effective against beetle larvae, butterfly, moth and caterpillars such as Mexican bean beetle, Colorado potato beetle and diamondback moth. Neem is very effective against grasshoppers, leaf minor and

leaf hoppers such as variegated grasshoppers, green rice leaf hopper and cotton jassids. Neem is fairly good in managing beetles, aphids and white flies, mealy bug, scale insects, adult bugs, fruit maggots and spider mites.

Some other pest control formulations

Many organic farmers and NGOs have developed large number of innovative formulations which are effectively used for control of various pests. Although none of these formulations have been subjected to scientific validation but their wide acceptance by farmers speak of their usefulness. Farmers can try these formulations, as they can be prepared on their own farm without the need of any purchases. Some of the popular formulations are listed below:

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

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

Dashparni extract – Crush neem leaves 5 kg, Vitex negundo leaves 2 kg, Aristolochia leaves 2 kg, papaya (Carica Papaya) 2 kg, Tinospora cordifolia leaves 2 kg, Annona squamosa (Custard apple) leaves 2 kg, Pongamia pinnata (Karanja) leaves 2 kg, Ricinus communis (Castor) leaves 2 kg, Nerium indicum 2 kg, Calotropis procera leaves 2 kg, Green chilly paste 2 kg, Garlic paste 250 gm, Cow dung 3 kg and Cow Urine 5 lit in 200 lit water ferment for one month. Shake regularly three times a day. Extract after crushing and filtering. The extract can be stored up to 6 months and is sufficient for one acre.

Neem-Cow urine extract - Crush 5 kg neem leaves in water, add 5lit cow urine and 2 kg cow dung, ferment for 24 hrs with intermittent stirring, filter squeeze the extract and dilute to 100 lit, use as foliar spray over one acre. Useful against sucking pests and mealy bugs.

Mixed leaves extract - Crush 3 kg neem leaves in 10 lit cow urine. Crush 2 kg custard apple leaf, 2 kg papaya leaf, 2kg pomegranate leaves, 2 kg guava leaves in water. Mix the two and boil 5 times at some interval till it becomes half. Keep for 24 hrs, then filter squeeze the extract. This can be stored in bottles for 6 months. Dilute 2-2.5 lit of this extract to 100 lit for 1 acre. Useful against sucking pests, pod/fruit borers.

Chilli-garlic extract - Crush 1 kg Ipomea leaves, 500 gm hot chilli, 500 gm garlic and 5 kg neem leaves in 10 lit cow urine. Boil the suspension 5 times till it becomes half. Filter squeeze the extract. Store

in glass or plastic bottles. 2-3 lit extract diluted to 100 lit is used for one acre. Useful against leaf roller, stem/fruit/pod borer

Broad spectrum formulation - 1: In a copper container mix 3 kg fresh crushed neem leaves and 1 kg neem seed kernel powder with 10 lit of cow urine. Seal the container and allow the suspension to ferment for 10 days. After 10 days boil the suspension, till the volume is reduced to half. Ground 500 gm green chillies in 1 lit of water and keep overnight. In another container crush 250gm of garlic in water and keep overnight. Next day mix the boiled extract, chilli extract and garlic extract. Mix thoroughly and filter. This is a broad spectrum pesticide and can be used on all crops against wide variety of insects. Use 250 ml of this concentrate in 15 lit of water for spray.

Broad spectrum formulation - 2: Suspend 5 kg neem seed kernel powder, 1kg Karanj seed powder, 5 kg chopped leaves of besharam (Ipomea sp.) and 5kg chopped neem leaves in a 20lit drum. Add 10-12 lit of cow urine and fill the drum with water to make 150 lit. Seal the drum and allow it to ferment for 8-10 days. After 8 days mix the contents and distil in a distiller. Distillate will act as a good pesticide and growth promoter. Distillate obtained from 150lit liquid will be sufficient for one acre. Dilute in appropriate proportion and use as foliar spray. Distillate can be kept for few months without any loss in characteristics.

V. Disease management

Occurrence of a disease requires a balanced interaction of host, pathogen, and environment. The disease management strategies under organic farming aim to disrupt this balance and disallow the pathogen to cause disease beyond economic injury level. Pathogens need suitable environmental conditions like humidity, temperature, moisture, host exudates etc to germinate, survive and infect. In absence of these pathogens cannot survive and perish. Most of the strategies described below interfere with the micro-environmental conditions to make them uncongenial for pathogen propagation, multiplication and initiating infection.

1. **Growing disease resistant varieties:** For low external input organic farming, resistant crops represent an important alternative to pesticides. Exploiting the diversity and variability in the host genetic constitution for resistance against a pathogen in a crop is the best strategy for disease management without application of hazardous pesticides as in case of mango use varieties like Elaichi, Alib and Bhaduran as malformation resistant varieties. Successful disease establishment depends on the

compatible gene for gene interaction between a host and a pathogen. However this strategy is very specific and tends to tackle only one or two diseases at a time owing to its resistance.

2. **Exclusion of pathogen:** Use of disease-free seeds and planting material would prevent seed borne disease, management of vectors, and in situ destruction of soil borne pathogens through soil solarisation or Anaerobic soil disinfestations (ASD) involves the incorporation of fresh organic material in moist soil under airtight plastic for 3–6 weeks, depending on the outside temperature (van Bruggen et al., 2016; Khulbe, 2000).
3. **Application of organic amendments:** Improving soil health through use of cover crops, green manures, animal manures to fertilize the soil not only helps in restricting soil borne pathogens but also maximizes biological activity and maintains long-term soil health. Organic amendments are biodegradable and are generally available on the farmer's fields. Neem cake used for soil amendment @ 0.25 to 0.5 t/ha contributes significantly in control of nematodes and soil borne pathogens.
4. **Cultural control:** From choosing the date of planting to field sanitation and weed management, the specific cultural measures reduce the initial load of inoculum and favourable conditions for growth of pathogens. Rotations can also be designed to minimize the spread of weeds, pests and diseases. However, crop rotation can be ineffective if the pathogen is long-lived in the soil with a wide host range. Ensuring good drainage is essential for disease management. Poor drainage in the fields not only reduces general health of the plant but also allows the pathogen to multiply rapidly. Many pathogens can survive on debris and weeds. Tilling and cleaning of plant residue at the end of the season allows break down of the organic matter, leaving potential pathogens without a host. Moderate fertilization induces steady growth and makes a plant less vulnerable to infection.
5. **Orchard bio-intensification:** The orchard bio-intensification concept envisages habitat modification for beneficial organisms, development of healthy and biologically active soils, maintaining uncultivated lands for diversity of flora and fauna, developing entomophage parks within orchard for

food and shelter to diverse beneficial insects, weed strips, hedge rows, wind breaks, inter crops and conservation of insect bio diversity (Singh and Srinivas, 2016).

6. **Physical methods:** Soil solarisation of nursery beds reduces soil borne inoculum. Hot water/steam treatment of seeds/planting material has been successful in many crops (Cohen et al., 2005).
7. **Botanicals, essential oils, baking soda, butter milk etc:** Spraying of neem oil, cow urine, panchgavya, and fermented butter milk are some of the most predominant methods of controlling pests and diseases by the organic farmers in India. Several researches indicate that application of many plant extracts may reduce incidence of foliar diseases. Application of horticultural grade oils has also proven to reduce disease incidence in many crops. Baking soda has been used to control mildew and rust diseases on plants. Application during hot weather and may though lead to possible phytotoxic effects. Butter milk sprays have been popular against blights, mildew, mosaic viruses and other fungal and viral diseases. Application of soft soap solutions and neem oil against viral vectors like aphids and other sucking insects is also effective. Cow dung ferments like 'Amrit-Paani' are widely used by organic farmers for enhancing crop growth and disease management. Such fermented solutions are known to have high bacterial population of cellulose degraders, nitrogen fixers, P-solubilizers, plant growth promoters and antagonists of disease-causing fungi (Venkateswarlu *et al*., 2008).
8. **Application of biocontrol agents:** Microbial bio-control agents isolated from native environments are relatively safe, host specific and do not disturb other biotic systems (Srinivas and Ramakrishna, 2005). Their mechanisms of action include competition, antagonism, antibiosis, enhanced nutrient uptake, induction of host resistance (Kloepper et al. 1997) etc. Unlike chemical pesticides, they are harmless to humans and other non-target organisms, they do not leave chemical residues on crops, are easy and safe to dispose of and do not contaminate water systems. These are available as powders for seed treatments, as granulars for soil application, and as suspensions for root drenches and foliar sprays. Biological

control agents like *Trichoderma spp*, *Pseudomonas spp* and *Bacillus spp*. have proven their worth in managing a range of plant diseases.

9. **Application of mineral based fungicides:** Prophylactic sprays of Sulphur are mostly used against plant diseases like powdery mildew, downy mildew and other diseases by preventing spore germination. Copper based fungicides and Bordeaux mixture (Copper sulphate and lime) have been successfully used on fruits, vegetables and ornamentals. Unlike sulphur, Bordeaux mixture is both fungicidal and bactericidal. It is effective against diseases such as leaf spots caused by bacteria or fungi, powdery mildew, downy mildew and various anthracnose pathogens. The ability of Bordeaux mixture to persist through rains and to adhere to plants is one reason it has been so effective. Copper hydroxide and copper oxychloride are accepted in organic farming provided that the number of applications is moderated to prevent copper accumulation in the soil.

VI. Weed management

Preventive measures

Once the weeds appear in the field they cause great trouble in various ways. Different preventive measures for weed control are: use of seeds from the reliable sources or to use certified seeds, preventing the entry of livestock into the crop land, cleaning the equipments such as harvesters, cultivators, seed cleaners etc before and after field operations, keeping the irrigation channels weed free, using only well rotten manures in which weed seeds have been decomposed by microorganisms and applying the fertilizers near the rows or plants and avoiding broadcasting.

Cultural practices

Crop rotation: The weeds such as *P. minor*, *A. fatua etc* which are associated with the specific crops can be controlled by means of crop rotation. These weeds can be managed in wheat field by growing pea, gram or potato in rotation.

Cover cropping: The vacant inter-row spaces in the fields provide space for weed growth and development. This space can be utilized for extra income by the farmers. The leguminous crops such as pea, *Urd*, cow pea etc are preferred for this purpose. This not only prevents weed growth but also replenishes soil nutrients and prevents soil erosion.

Hoeing and hand pulling: Hoeing and hand weeding are the most commonly used practices. These practices completely destruct the shallow rooted weeds. These also help in aeration of soil and breaking of capillaries by

hoeing thus preventing evaporation of soil water.

Water management

Flooding: This method is very helpful in some crops such as paddy. Paddy plants can grow well in the submerged conditions but weeds can not do so. Water is kept standing in the field for 6-8 weeks.

Drip irrigation: In some cases flooding helps in proliferation of weeds especially the summer and winter season weeds Therefore irrigation should be done as per the requirement of plants. For this purpose drip irrigation is very successful alternative especially for horticultural crops.

Mulching: Mulches not only contribute for weed management but also conserve soil moisture and maintain the soil temperature necessary for growth and development of the plants. Different mulches which can be used for weed management are explained hereunder:

Organic mulching: The crop residues, pine needles, paddy straw etc can be utilized to check the weed growth which act as organic mulches. Organic mulches also prove to be an excellent mean for soil moisture conservation especially in winters and summers.

Inorganic mulches: To check the weeds the mulch must block nearly all the light that reaches the soil so that weeds which emerge underneath the mulch do not have enough light to survive. Sometimes the black polythene mulch may be used for such purpose.

Living mulches: Living mulches are usually plant species which do not attain much height such as clover planted before or after a crop. Living mulches should be well managed to avoid competition with main crop. Inter-row spaces can be utilized for living mulches.

Use of primed seeds: Seed priming in an osmotic solution (PEG 6000, mannitol, cocopeat, vermiculite, KCl, KNO3 etc) before sowing that enhances germination and increases seedling emergence uniformly under adverse environmental conditions. The desirable crop will emerge faster than weeds and therefore prevent the growth of weeds by cutting off the supply of light and nutrients.

Soil solarisation: Soil solarisation controls soil borne pests using radiant enery from the sun. This is very effective method to kill the weeds especially in summers or before onset of winters. The soil is irrigated first to promote weed emergence and then covered with clear plastic film after tillage. The heat trapped inside kills the weeds and also kills the embryos inside the dormant seeds.

Plant geometry: Different studies have shown that the closer planting of crops gives perfect competition to weeds by reducing the amount of light and nutrients required for weeds.

Mechanical control

Tillage/cultivation: Tillage between the rows or the cultivation of fallow land twothree times causes significant reduction in weed population. For this disc harrow, cultivator etc may be used with power tiller or tractor.

Flame method: The weeds that emerge before the main crop can be managed by a hot flame passed quickly over them. The weeds between the rows can be easily killed. This is particularly very useful in crops which take longer time to emerge such as carrot. An advantage of this method over the tillage or cultivation is that it does not disturb the soil and also does not promote the germination of the dormant weeds.

Stale seedbed technique: Stale seedbeds are prepared 2-4 weeks prior to crop seeding in which weeds are allowed to emerge and killed while they are still small by shallow cultivation. This can be repeated twice or thrice depending upon the availability of time. This technique significantly reduces the weed population that emerges after the crop is planted.

Mowing: Mowing can be done in the interrow spaces. Regular mowing is needed to prevent the weed-crop competition and also to prevent the weeds to shift into reproductive phase thus preventing weeds' seed production for next generation.

Summer ploughing: The advantage of summer ploughing may be taken by exposing the weed seeds to various environmental stresses.

Biological control: It involves utilization of living organisms/plants such as insects, fungi, competitive crops, allelopathic crops and herbivorous fishes for the suppression/ control of the weed population.

IV. Rejuvenation

Rejuvenation can also be applied for maintaining organic fruit orchard as it successfully practised in mango, guava, ber, aonla, litchi *ect.* The term 'Rejuvenation' means renewal or making new or young again. As applied to the orchard tree it would mean restoring the productive capacity of the fruit includes removal of old twigs, restoration of new shoots and grafting of desired variety on these newly emerged shoots. The process may take 2-3 years to be effective.

The old fruit orchards need to be rejuvenated as they show decline in yield and quality of produce which may be attributed to any one of the following factors:

- Reduction in the photosynthetic surface area.
- Non availability of productive shoots.
- Increased incidence of insect pests and diseases.

- Less penetration of sunlight due to overcrowding of branches as a result of which the fruits on the interior areas of the tree do not develop proper colour.

Principles of rejuvenation:

- Trees have latent buds which are activated by heading back of branches at certain point to put forth new sprouts which grow into branches forming fruiting area.
- When the branches are cut back, imbalance is created in root:shoot ratio as a result new shoots arise from plant to balance it.

Technique of rejuvenating senile orchards:

The rejuvenation technology involves the heading back of unproductive trees to the extent of 1.0 to 1.5 m height above the ground level during May-June or December-February. The objective of heading back is to facilitate production of new shoots from below the cut point and allow the development of fresh canopy of healthy shoots. The newly emerging shoots are allowed to grow up to 40-50 cm length and then further pruned for emergence of multiple shoots below the pruning point to modify the tree structure and maintain canopy size. Profusely emerging shoots in the inner canopy are also pruned out to promote branching. After second pruning , multiple shoots developed which are capable of producing flower buds.

Quality Regulation

Organic fruit products are required to be certified by accredited agencies to indicate that they have been produced, stored, processed, handled, and marketed in accordance with technical specifications. The organic label is a production process claim, as opposed to a product quality claim. India now has 26 accredited certification agencies to facilitate the certification of growers. In India, the Tea Board, Coffee Board, Spices Board, and Coconut Development Board have developed guidelines for production and certification, and have encouraged the production and export of organic produce and products. Recognizing the need for organic farming, the Ministry of Agriculture has also taken the major initiative that production and certification for domestic markets shall be the responsibility of the Ministry of Agriculture. There are now over 150 countries in the world exporting certified organic products. Organic trade is expanding at the rate of 15%–20% per year. Over 500 public and private certification bodies now operate in the global organic market place (Mitra, 2013). The many governmental and private standards and technical regulations governing organic production and certification have placed a burden on producers and traders and created

barriers for trade on many levels. There is a need for tools to be in place to support equivalency and harmonization in the global organic trade. By cooperation within and among governments and the private sector, trade barriers can be reduced.

Organic Certification

It is a certification process for producers of organic food and other organic agricultural products. In general, any business directly involved in food production can be certified, including seed suppliers, farmers, food processors, retailers and restaurants. Requirements vary from country to country, and generally involve a set of production standards for growing, storage, processing, packaging and shipping that include:

- Avoidance of synthetic chemical inputs (e.g. fertilizer, pesticides, antibiotics, food additives, etc) and genetically modified organisms;
- Use of farmland that has been free from chemicals for a number of years (often, three or more);
- Keeping detailed written production and sales records (audit trail);
- Maintaining strict physical separation of organic products from non-certified products;
- Undergoing periodic on-site inspections.

Certification system in India

In India, there are two accreditation systems for authorizing Certification and Inspection agencies for organic certification. National Programme on organic Production (NPOP) promoted by Ministry of Commerce is the core programme which governs and defines the standards and implementing procedures. National Accreditation Body (NAB) is the apex decision making body. Certification and Inspection agencies accredited by NAB are authorized to undertake certification process. The NPOP notified under FTDR act and controlled by Agricultural Processed Foods Export Development Authority (APEDA) looks after the requirement of export while NPOP notified under APGMC act and controlled by Agriculture Marketing Advisor, Directorate of Marketing and Inspection looks after domestic certification. Currently 20 certification agencies have been authorized to undertake certification process Details of the system are available at www.apeda.com/npop. In 2006, India's organic certification process under NPOP has been granted equivalence with European Union and Switzerland. It has also been recognized for conformity assessment by USDA's NOP.