

# **Advances in Organic Farming**

**Volume – 1**

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**Scripown Publications  
New Delhi**

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**Chief Editor:** Prof. Dr. Sanjay Swami

**Edition:** 1st

**Publication Year:** 2022

**Pages:** 96

**ISBN:** 978-93-90833-24-5

*Scripown Publications*

*2nd Floor, 304 and 305, Pocket - 4,  
Sector - 22, Rohini, North West Delhi,  
Delhi, 110086, India*

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# Chapter - 1

## Vermicomposting: An Ecofriendly Approach for Sustainable Agriculture

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### Abstract

The soil of the earth is a very important segment of agriculture. Soil provides primary nutrient cycling for plant and animal life and acts as a basis for feed, fuel, fiber, and medical products as well as for many critical ecosystem services. Fertile soil on the planet has been diminishing gradually due to the application of chemical fertilizers on the soil. Vermicomposting is an alternative option to reduce the stress on land and contributes to sustainable development. Krishi Vigyan Kendra, Deoghar implemented a project to convert floral offering waste collected from Baba Baidyanath temple into vermicompost and sell it among local farmers.

This chapter highlighted vermicompost can be just as profitable for both the manufacturers as well as consumers, its nutritive value to enhance the fertility of the soil, methods and steps of vermicomposting to understand how to do it in the right way to avoid error in producing good quality of compost.

**Keywords:** Ecofriendly, vermicompost, organic

### Introduction

Vermicomposting an ecofriendly approach to reduce organic waste and convert it into useful product which can use for organic manure in farming. This approach was used to reduce organic waste produced in Baba Baidyanath Temple throughout the year. Baba Baidyanath temple is one of the twelve Jyotirlinga in India and considered to be the most sacred abodes of Lord Shiva. It is located in the district of Deoghar which receives significant devotees. Temple complex consist main temple along with 21 other temples in same premises. Millions of pilgrims visit this sacred place every year most importantly at the time of shravana (between July and august). These devotees present floral offering to lord shiva. These floral offerings used to generate lot of organic waste in the temple premises. So, an initiative was taken to convert

this waste into useful organic manure with the help of earthworm which is far better than synthetic fertilizer.

Earthworms living in soil and feed decaying organic material. Digestion of organic materials and indigestible material move through alimentary canal of earthworm, also thin layer of oil is deposited on by castings. This layer erodes over near about after 2 months. Although plant nutrients are immediately available, these are slowly released to last longer. Processing in alimentary canal of earthworm transforms organic waste to natural fertilizer for soil. Organic wastes undergo includes deodorizing and neutralizing by chemical changes. It means pH of castings is neutral and the castings are odorless. Worm castings also contain bacteria; therefore, these processes occur in soil and microbiological activity.

*Vermicomposting* is a process of turning organic materials into castings by earthworms. These castings are an important factor for the soil fertility. Castings almost contain more available nitrogen, available potash and calcium than found in good topsoil viz., 5, 7 and 1.5 times more, respectively. Earthworm castings also contenting the natural tillage by worms burrowing action and enhances the permeability of water in soil. Worm castings can closely hold nine times water compared to their weight. Earthworms to convert waste into soil additives that is called as “Vermiconversion” could be done as relatively small scale. Recommendation of vermicompost application is generally using 15-20 percent.

### **Characteristics & Advantage of Vermicompost**

Vermicompost convert organic waste into stabilized organic matter by the bacteria in worm's gut and that make it so beneficial to plant.

**Physical characteristics:** it has high nutrient holding capacity, fine particulate structure, granulated, high surface area and high-water holding capacity.

**Biological characteristics:** it contains active bacteria, active fungi, high microbial populations and high microbial diversity.

**Chemical characteristics:** it has near to neutral pH, humic acids, contain plant recommended nutrient and plant hormones like auxins, gibberellins etc.

These characteristics make vermicompost suitable manure for plant growth and improve the health of soil.

### **Advantages of vermicompost**

- Accelerate Germination process of seed

- Yield of fruits increase
- Nutrient present in vermicompost released slowly as needed which make nutrient available for crop throughout the season.
- Presence of Humic acid in it make healthier plants and nutrient dense produce which contributor to pest and disease resistant.
- Improve the soil health (physically, chemically and biologically) and maintain healthy soil food web.
- Most importantly it is environmentally friendly

### **Nutritive Value of Vermicompost**

The nutrients content in vermicompost vary depending on the waste materials that is being used for compost preparation. If the waste materials are heterogeneous one, there will be wide range of nutrients available in the compost. If the waste materials are homogenous one, there will be only certain nutrients are available. The common available nutrients in vermicompost are as follows:

|                       |                                  |
|-----------------------|----------------------------------|
| Organic carbon        | 9.5 – 17.98%                     |
| Nitrogen              | 0.5 – 1.50%                      |
| Phosphorous           | 0.1 – 0.30%                      |
| Potassium             | 0.15 – 0.56%                     |
| Sodium                | 0.06 – 0.30%                     |
| Calcium and Magnesium | 22.67 to 47.60 meq/100g          |
| Copper                | 2 – 9.50 mg kg <sup>-1</sup>     |
| Iron                  | 2 – 9.30 mg kg <sup>-1</sup>     |
| Zinc                  | 5.70 – 11.50 mg kg <sup>-1</sup> |
| Sulphur               | 128 – 548 mg kg <sup>-1</sup>    |

### **Vermicompost Production Methodology**

Temple administration taken great initiative to overcome ample amount of organic waste procure from temple by installing 2 PowerGrid. Machine was installed to grind the waste into small shreds which are suitable for further process. The whole organic waste is being converted into Vermi compost with the help of these shredded material. The shredded material is mixed with earthworms and cow dung to convert it into vermin compost. To convert it into vermicompost, the mixture is handled at an optimum temperature and humidity for 70-75 days. In the preparation vermicompost following things must be remembered.

## **Selection of Suitable Earthworm**

For the vermicompost production, surface dwelling earthworm alone is very suitable. Earthworm, which lives below the soil, is not suitable for vermicompost production. African earthworm (*Eudrillus engehardi*), Red worms (*Eisenia foetida*) and composting worm (*Perionyx excavatus*) are promising worms used for vermicompost production. All the three worms can be mixed together for vermicompost production.

## **Selection of Site for Vermicompost Production**

Vermicompost can be produced in any place with shade, high humidity and cool. Abandoned cattle shed or poultry shed or unused buildings can be used. If it is to be produced in open area, shady place is selected. A thatched roof may be provided to protect the process from direct sunlight and rain. The waste heap for vermicompost production should be covered with moist gunny bags.

## **Containers for Vermicompost Production**

Cement tub may be constructed to a height of 2.5 feet and a breadth of 3.0 feet. Length may be fixed to any level depending upon the size of room. Bottom of the tub is made to slope like a structure for drain the excess water from vermicompost unit. A small sump is necessary to collect the drain water.

## **Vermiculture Bed**

Vermiculture bed or worm bed (3 cm) can be prepared by placing after saw dust or husk or coir waste or sugarcane trash in bottom of tub/container. A layer of fine sand (3 cm) should be spread over the culture bed followed by a layer of garden soil (3 cm). All layers must be moistened with water.

## **Common Bedding Materials and Their Properties**

In general, it should be noted that the selection of bedding materials is a key to successful vermicomposting. Worms can be enormously productive if conditions are good. Good bedding mixtures are an essential element in meeting those needs. They provide protection from extremes in temperature, necessary levels and consistency of moisture and an adequate supply of oxygen.

## **Worm Food**

Compost worms are big eaters. Under ideal conditions, they are able to consume in excess of their body weight each day, although the general rule of thumb is 0.5 of their body weights per day. They will eat almost anything organic, but they definitely prefer some foods to others. Manures are the most commonly used worm feedstock, with dairy and beef manures generally

considered the best natural food for Eisenia, with the possible exception of rabbit manure.

### **Putting the Waste in the Container**

Predigested waste material should be mud with 30% cattle dung either by weight or volume. The mixed waste is placed into the tub / container upto brim. The moisture level should be maintained at 60%. Over this material, selected earthworm is placed uniformly. For one-meter length, one-meter breadth and 0.5-meter height, 1 kg of worm (1000 Nos.) is required. There is no necessity that earthworm should be put inside waste. Earthworm will move inside on its own.

### **Watering the Vermin-Bed**

Daily watering is not required for vermin-bed. But 60% moisture should be maintained throughout the period. If necessity arises, water should be sprinkled over the bed rather than pouring water. Watering should be stopped before the harvest of vermicompost.

### **Harvesting Vermicompost**

In the tub method of composting, castings formed on top layer are collected periodically. Collection may be carried out once in a week. With hand the casting will be scooped out and put in a shady place as heap like structure. The harvesting of casting should be limited up to earthworm presence on top layer. This periodical harvesting is necessary for free flow and retains the compost quality. Otherwise, the finished compost gets compacted when watering is done. In small bed type of vermicomposting method, periodical harvesting is not required. Since the height of waste material heaped is around 1 foot, produced vermicompost will be harvested after the process is over.

### **Harvesting Earthworm**

After the vermicompost production, the earthworm present in the tub / small bed may be harvested by trapping method. In the vermin-bed, before harvesting the compost, small, fresh cow dung ball is made and inserted inside the bed in five or six places. After 24 hours, cow dung ball is removed. All the worms will be adhered into the ball. Putting the cow dung ball in a bucket of water will separate this adhered worm. Collected worms will be used for next batch of composting. Worm harvesting is usually carried out in order to sell worms, rather than to start new worm beds. Expanding the operation (new beds) can be accomplished by splitting the beds that is, removing a portion of the bed to start a new one and replacing the material with new bedding and

feed. When worms are sold, however, they are usually separated, weighed and then transported in a relatively sterile medium, such as peat moss. To accomplish this, worms must first be separated from the bedding and vermicompost.

There are two basic categories of methods used by growers to harvest worms: manual, migration and mechanical.

- **Manual Methods**

Manual methods are commonly used by small scale grower or the one who keeps interest in it. This process can be facilitated by taking advantage of the fact that worms avoid light. If material containing worms is dumped in a pile on a flat surface with a light above, the worms will quickly dive below the surface. The harvester can then remove a layer of compost, stopping when worms become visible again. This process is repeated several times until there is nothing left on the table except a huddled mass of worms under a thin covering of compost. These worms can then be quickly scooped into a container, weighed and prepared for delivery. There are several minor variations and/or enhancements on this method, such as using a container instead of a flat surface or making several piles at once, so that the person harvesting can move from one to another, returning to the first one in time to remove the next layer of compost.

- **Self-Harvesting (Migration) Methods**

These methods, like some of the methods used in vermicomposting, are based on the worm's tendency to migrate to new regions, either to find new food or to avoid undesirable conditions, such as dryness or light. Unlike the manual methods described above, however, they often make use of simple mechanisms, such as screens or onion bags. The screen method is very common and easy to use. A box is constructed with a screen bottom. The mesh is usually ¼", although 1/8" can be used as well. There are two different approaches. The downward migration system is similar to the manual system, in that the worms are forced downward by strong light. The difference with the screen system is that the worms go down through the screen into a prepared, pre-weighed container of moist peat moss. Once the worms have all gone through, the compost in the box is removed and a new batch of worm rich compost is put in. The process is repeated until the box with the peat moss has reached the desired weight. Like the manual method, this system can be set up in a number of locations at once, so that the worm harvester can move from one box to the next, with no time wasted waiting for the worms to migrate.

## **Marketing of Vermicompost**

Vermicompost not only convert waste into manure but also give good amount of return by selling it. It is available under different type of packet according to weight like 5kg, 10 kg, 25 kg based on demand by different stakeholder. The price of compost is decided by district administration. Presently it is being sold at 5 rupees per kg.

## **Conclusion**

Floral offerings used to generate lot of organic waste in the temple premises and to get rid of this waste this project was came into existence. This happened only due to the joint effort of temple administration, technical support by Indian institute of soil science Bhopal and Dr. Rajendra Prasad central agriculture university Samastipur along with implementing institute Krishi Vigyan Kendra, Deoghar. After implementation of project there is not a single leaf of offering strewn on the temple precincts. Based on this cleanliness initiative this temple has been given Swachh iconic places award.

# Chapter - 2

## Importance of Indigenous Technical Knowledge Systems in Organic Farming

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### Abstract

Traditional knowledge encompasses belief systems that play a fundamental role in people. This traditional knowledge includes mental inventories of local biological resources, animal breeds, local plant and tree species. Traditional knowledge mainly includes information about trees and plants that grow being together, about indicator plants that show the soil salinity, or known to flower at the beginning of the rains. It includes practices and technologies, such as seed treatment and storage methods, and tools used for planting and harvesting.

**Keywords:** Crop Production, Crop Protection, Constraints, Importance and Organic farming.

### Introduction

“Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved”.

Variations in the Indian agro-climate from tropical to temperate

conditions have lead to the development of indigenous skills based on innovations at farmers' fields. Unfortunately, these skills do not find much appreciation, as these are not tested in the field by researchers. Although many of these traditional practices are supported by scientific findings, yet these have not been converted into technological recommendations to enable farmers to reduce their costs and make agriculture more sustainable. Such skills are termed as Indigenous technical knowledge.

Farmers constantly learn and unlearn, choosing appropriate knowledge in their struggle for a sustainable livelihood. Let's take a look at a few important a few important examples of ITK still prevalent in field:

Milk treatment: Reduction of viral diseases has been found to occur mostly in infected plants of Solanaceae, Piperaceae and Malvaceae families by milk spray. It was tested that fresh milk spray reduces nearly 73 per cent of TMV infections in tobacco. Fermented buttermilk (1l in 20 l of water) sprayed on tobacco plants cures leaf curl disease. Fresh goat milk sprayed over plants like chilli (*Capsicum annum*), brinjal and species like black pepper also helps control fruit and leaf curl. The neutral to near neutral pH of milk not only washes off the fungal spores but the adhesive property of milk fat also prevents germination of spores.

### **Why Organic Cultivation**

- No hazardous agrochemicals and their residues.
- Conservation of Environment and Quality of produce.
- Environment - Pollution free, resulting into healthy biosphere.
- Better premium price – Internal markets and export potential.
- Organic agriculture is labour intensive and generates rural employment.
- Provides better conditions for growth of micro-organisms in the rhizosphere.
- Better utilization of local resources and less dependency of expensive external inputs.
- Organically produced crops contain higher nutrients, vitamins and less nitrate so better in taste (Organic Retailers and Growers Association of Australia).

### **ITK'S Historical Information:**

Elderly are being regarded as invaluable national resource having adaptive and useful information which is time tested and is preserved from

generation to generation through oral or trial methods. Old methods, old materials and old products signify the traditional wisdom, which may have relevance even in the contemporary context. Thus, elders are to the requirements of local population and tapping the available resources. ITK has the potential of being translated into commercial benefits through development of useful products and processes. Modern science can give broader perspective to local sustainability whereas traditional knowledge provides the in depth experience in the local context.

### **Current Status of ITK'S:**

Livelihood, maintaining their health, and protecting and replenishing the environment presently, the loss of biological diversity and erosion of traditional knowledge systems (TKS) are issues of great concern. Most of these systems of knowledge are unique and are often known only to a few individuals or communities. This traditional knowledge includes mental inventories of local biological resources, animal breeds, local plant, and crop and tree species. Traditional knowledge may include information about trees and plants that grow well together, about indicator plants that show the soil salinity, or are known to flower at the beginning of the rains. It includes practices and technologies, such as seed treatment and storage methods, and tools used for planting and harvesting. Traditional knowledge encompasses belief systems that play a fundamental role in people.

### **Presently ITK's Used in Different Ways Are:**

1. Primary healthcare
2. Physical and mental health
3. Food processing and food habits
4. Animal healthcare practices
5. Plant protection and post-harvest management
6. Weather forecasting
7. Sustainable natural resources management
8. Soil and water management.

### **Components of Indigenous Technical Knowledge for Organic Farming:**

Organic farming deals with various components like green manuring, NADEP composting, bio fertilization etc. it is therefore essential to address the potentialities of the components for working out their use in organic agriculture.

## **Components of ITK's in Organic Farming:**

1. Green Manuring
2. Role of cow in Agriculture
3. Organic Manuring
4. Vermi-Composting
5. Crop Rotation
6. Cultural and Physical Management
7. Crop Hygiene
8. Genetic Resistance
9. Habitat Management
10. Trap crops and Inter cropping
11. Biological control
12. Botanical pesticides
13. Bio-dynamics.

### **Green manuring:**

#### **1. Green Manures:**

Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest. Green manuring is growing in the field plants usually belonging to leguminous family and incorporating into the soil after sufficient growth. The plants that are grown for green manure known as green manure crops. The most important green manure crops are sunnhemp, dhaincha, pillipesara and cluster bean

#### **2. Green leaf manure:**

Application of green leaves and twigs of trees, shrubs and herbs collected from elsewhere is known as green leaf manuring. Forest tree leaves are the main sources for green leaf manure. Plants growing in wastelands, field bunds etc., are another source of green leaf manure. The important plant species useful for green leaf manure are neem, mahua, wild indigo, Glyricidia, Karanji (*Pongamia glabra*) calotropis, avise (*Sesbania grandiflora*), subabul and other shrubs.



## Role of Cow in Agriculture:

The role of cow is well established in village. However, mechanization of agriculture and chemical fertilization reduced the dependency on animal. In indigenous method of cultivation the cow dung and urine manure are used for nutrition supplementation and also pest management. The use of cow dung and urine is as below.

1. Cow dung and urine
2. Compost enrichment compost
3. For vermin compost preparation
4. Bio dynamics preparation.

## Organic Manure:

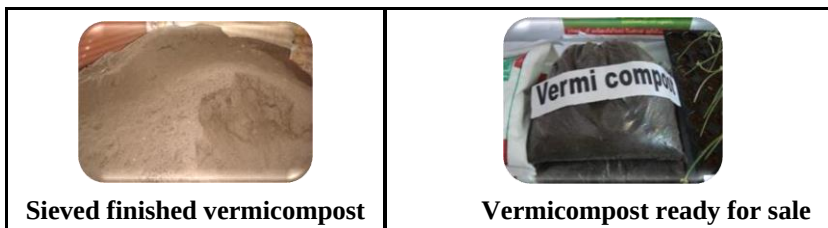
Manure are defined as the plant and animal waste which are used after decomposing as source of plant nutrient organic manure and crop residue are important sources of plant nutrient locally available material of plant and animal dung and urine may be re cycled and used as farm yard manure or compost for plant nutrient supply.

## On the basis of concentration of nutrient manures can be grouped into

- i. Bulky organic manure
- ii. Enriched organic manure
  - i. **Bulky organic manure:** It contains small percentage of nutrient and they required in large quantity. FYM, compost and green manure are the most important and widely used bulky organic manure.
  - ii. **Enriched organic manure:** Concentrated organic manure have higher nutrient than bulky organic manure.

## **Vermi-composting:**

Vermi-composting is the process of bioconversion wastes into quality compost through earth worm's consumption. They effectively harness the beneficial soil micro-flora, destroy soil pathogen and convert organic waste into viable product such as bio-fertilizer, vitamin enzymes, antibodies, growth hormones and enriched biomass. The nutrient availability through vermin-compost varies from materials used.



## **Crop Rotation:**

The practice of changing the species (or) families of annual and/or biennial crops grown on a specific field in a planned pattern or sequence so as to break weed/pest and disease cycle and to improve soil fertility and organic matter is called crop rotation. Planting the same crop in the same location time after time (mono cropping) encourages the build-up of diseases and pests that plague that particular crop. Crop rotation helps in overcoming this problem without the use of any chemicals.

The crop rotation is important for obtaining maximum yield in cropping system mode. A planned crop rotation will helpful to control weeds, nutrient recycling and there will be less build-up of fungus, pest complex and nematodes.

## **Cultural and Physical Management:**

The aim is to get healthy crop by sanitation; clean cultivation, which is most important in organic farming. A number of cultural or physical techniques continue to be used in agriculture since the origin of agriculture together with our civilization. These methods include:

- a. Weed/disease management by manual methods (roughing).
- b. Insect management control by hand picking of egg masses or larvae
- c. Diseases management by removing infected plant/ crop debris and burying in compost pits for destruction of infectious pest/ larvae/ eggs during composting.

## **Crop Hygiene:**

Traditional ploughing inverts the soil and buries up crop and weeds before the preparation of seed bed for the succeeding crop, which can also lead to increased erosion. Removal of crop residue which contains aggregated egg masses and larvae provides an essentially effective way of reducing survivals of some pests to the next season.

## **Genetic Resistance:**

Selection of proper crop variety may reduce the need for use of botanical or bio-pesticide. This also encourages survival of beneficial microbes and insects.

## **Habitat Management:**

Protection of natural habitats within the farm environment is recognized as a mean of conserving many of the natural enemies of pest which either difficult to rear in laboratory (or) not economical. Careful management of the margins of farmland as well as growing tree crops or hedges is particularly important because they provide habitat, cover and refuge for beneficial insects and other animals.

## **Trap Crops and Inter-Cropping:**

Sometimes a pest can be attracted away from a valuable sensitive cash crop by another crop which suffers less damage if attacked (e.g. coriander and linseed is sown in rows every 10-15 cm across chickpea fields to attract ball worms during critical periods of crop improvement. Growing of *Sesbani rotrata* in bunds attracts gurdle beetle in soybean.

## **Biological Control:**

This is used for specially chosen living organisms to control a particular pest. This chosen organism can be predator, parasite or disease which will manage the harmful insect. It is a form of manipulating conditions for bio-control agent population to get the desired effect.

## **Botanical Pesticides:**

Botanical sources of secondary metabolites or allelochemicals that provide for the fundamental or physiological or biochemical process of the plant. As many as 2121 plant species have been reported to possess pest control properties, 1005 species have insecticidal, and 384 anti-feedants, 297 repellents, 27 attractants and 31 growth inhibiting properties but not many could find their way to commercialization. Insecticides formed the key tools for management of pests and diseases in organic farming system.

This Botanical pesticide has been used as broad spectrum Pesticide which works against various diseases, pests, insects that attacks the plants. The use of this pesticide has been very effective in controlling diseases. Pests in plants that is grown organically. In herbal, Eucalyptus oil, Pine oil, Neem oil, citronella, various Herbal extracts, aromatic oils etc. Which generally are known to work against various insects and pests.

### **Biodynamics:**

A distinguishing feature of biodynamic farming is the use of nine biodynamic preparations describe by Steiner for the purpose of enhancing soil quality and stimulating plant life. They consist of mineral, plant, or animal manure extracts, usually fermented and applied in small proportions to compost, manures, the soil, or directly to plants after dilution and stirring procedures called dynamizations.

Biodynamic preparations are intended to help moderate and regulate biological processes as well as enhance and strengthen the life (etheric) forces on the farm. However, systematic research is needed on these aspects.

### **Panchagavya:**

It is a special preparation made from five by products of cow along with certain other ingredients are fresh cow dung, cow urine, cow milk, cow curd, cow ghee. The ingredient from local cow breed is debatable issue.

### **Dasagavya:**

It is an organic preparation made from ten products in the form of panchagavya and certain plant extracts. “Gavya” is the term given to cow’s products comprising of cow dung, cow urine, cow’s milk, curd and ghee, which have miraculous effects on plant growth when suitably mixed.

### **Cosmic Rhythms:**

The light of the sun, moon, planets and stars reaches the plants in regular rhythms. Each contributes to the life, growth and form of the plant. By understanding the gesture and effect of each rhythm, field preparation, sowing, cultivating and harvesting to the advantage of the crops are suggested during ancient time. However, in modern agriculture the time of sowing related to monsoon and moisture in soils.

### **Agnihotra:**

Agnihotra is the ancient most Vedic science of bio-energy. It is claiming that tremendous amounts of energy gathered near the agnihotra copper pyramid just at agnihotra time. Plant receives nutrition from agnihotra

atmosphere, become happy and grow well. The agnihotra is ancient method of purifying atmosphere. But yield increase or insect-pest control through agnihotra is questionable and debatable issue.

### **Insect Pest and Disease Management**

The basis of insect, disease and nematode management in organic farming systems is the reliance on the inherent in nature. Most insect pests have natural enemies of pests of tea have been identified. In organic tea estates, however, emphasis should ideally be on the use of varieties resistant to pests. Neem based pesticide are used in the organic gardens to repel certain sucking pests. The extracts derived from the aerial parts (leaves and stem) of *Artemisia vulgaris*, *Urtica dioica*, *Polygonum runcinatum* and *Eupatorium glandulosum* which are profusely growing in the tea plantations of Darjeeling hills are used for their repellent and antifeedant action against some leaf eating pests.

Cultural control probably the most economical and widely applicable method of pest control. In tea estates, routine cultural operations such as mulching, plucking, pruning, regulation of shade and drainage which increase the bush plays a predominant role in suppression of pests. Infestation by mites and thrips is seen tea fields devoid of shades. The heavily shaded and most areas are seen to be damaged more by tea mosquito bug (*Helopeltis theivora*). Leaf folding caterpillars such as leaf rollers (*Caloptilla theivora*), tortrix (*Homona coffearia*) and flush worms (*Cydia leucostoma*) could be manually removed while plucking. Manual removal of caterpillars (*Euterpeia* sp.) In some situation, few rounds of black plucking seen to be useful to be useful to reduce the incidence of thrips and helopeltis etc. Further, weed control in the tea fields at the appropriate time is essential since weeds serve as alternate hosts for many tea pests for example *Helopeltis*. One of the most important leaf diseases in tea is blister blight caused by the fungus *Exobasidium vexans*. The spray of the cell suspension of *Pseudomonas fluorescens* at 109 cfu/ml, every 15 days for three months on infested plants, significantly reduced to the disease 72-83 percent (Acharya *et al.*, 2001). Some parasitic wasps viz. *Apanteles* sp. and *trichogramma* sp. Were used widely in the organic tea gardens of China to control the larvae of looper caterpillar and tea small roller (*Adoxophes* sp.) respectively. Use of volatile allelochemicals to attract the natural enemies of tea pests is also very common in China. Entomopathogenic fungi such as *Hirsutella thompasoni*, *Poecilomyces fumosoroseus* and *verticillium lecanii* are moderately effective against tea mites and certain plant sap feeding insect pests. *Bacillus subtilis* was found effective in the control of black rot

disease caused by *Corticium invisium* and *Corticium theae*. The mineral originated pesticides such as Bordeaux mixture and lime sulphure were limited to use during non-plucking season for control of some scales, mites, whiteflies and tea disease in the organic tea estates of china. However, these methods of pest control need to be thoroughly evaluated.

### **Weed Management:**

Complete eradication of weeds does not generally occur in the organic farms. Weeds in general are controlled in organic orchard by adopting the following eco-friendly practices.

### **Mulching:**

Advantage of mulching in the form of protecting soil from the beating effect of heavy rainfall, suppression of weeds, checking of surface runoff, preservation of fertile top soil from erosion, multiplication of the bacterial population of the soil ensuring better plant nutrient availability and conservation of soil moisture are well established. In addition, mulches decompose over a period of time *Mimosa*, *Tephrosia*, *Sesbenia* and grasses viz. *Guatemala (Tripasicum laxum)* *Mana grass (Cymbopogon confertiflorus)* and lemon grasses clipping etc are used for mulching.

### **Cover Cropping:**

Seeds of *Mimosa invisa*, *Crotalaria angyroides*, *African magnolidae*, *Flemingia crotalaria*, *Pennisetum purpureum*, *Trifolium dubium*, *T. ripens*, *T. pretens* are generally sown before rains. It has been noticed in some areas that *Mimosa invisa* in combination with *Tripsacum laxum* suppressed weed growth, improving soil structure and fertility, and was also found helpful in lowering soil temperature during summer months. Cover crops can be grown between the tea rows and in walking rows.

### **Nutrient Management:**

High quantities of nutrients are lost through the continual plucking of tea leaves. Growing leguminous crops (shade trees, cover crops, green crops etc.) would be a good source for the supply of nutrients. Two-tier mixed shade canopy source of important plant nutrients is also important for organic tea estates. organic tea estates, nutrients are being supplemented using well composted farmyard manures, biogas slurry, neem cakes, lopping of green manures, shade tree droppings etc. spent mushroom substrate has many positive attributes still left for potential use as good nutrient sources. The nutrient status of spent mushroom substrate is higher than that of the original material, which can further be enhanced by composting after amending with cow dung. Requirement of potassium is usually met by the

addition of wood ash. Basic slag, natural rock phosphate, limestone, chalk, gypsum etc. are used occasionally with the prior approval of the inspections body.

### **Biodynamic Preparations:**

- i. **Cow horn manure (BD 500):** Straw-free dung of a lactating cow was filled into uncovered cow horns and buried in the ground during autumn and winter months.
- ii. **Horn silica (BD 501):** This silica spray is based on very finely ground quartz, or silica. The quartz is powered by crushing it with a pounding stone, a mortar and pestle and finally ground between glass plates. The powder is made into slurry by adding water packed into the horns and buried during the spring and summer months (March-April) the horns are dug out of the ground in Sep-Oct and stored in transparent glass containers near window sill.
- iii. **BD 506:** wilted dandelion flower leaves are sewed in cow mesentery and sun dried; it separates the metabolic from the respiratory system of the heap.
- iv. **BD 507:** extract of valerian flower, stored in dark bottles; acts as the thermostat of the heap, regulating its temperature.
- v. **BD 508:** Dried equisetum shoots – tea is made in vat, covered and filled with rain. The tea is sprinkled which acts the immune system of the compost heap.

### **Organic Certification:**

Market growth is a reflection of industry growth, and certification is a tool of the market. The entire production chain from the producer up to the exporter and importer of organic tea has to be inspected by independent and neutral bodies (certification bodies) that are operating according to specific guidelines. Certification is not a one-time procedure, but is an ongoing monitoring and inspection system. Basic requirements for certification of organic products can be summarized as follows.

- Minimum one full inspection year
- Full implementation of the relevant standards
- Conversion period to be followed
- No parallel production; Sustainable production system
- Identification of product flow and audit procedure
- Clear management responsibilities.

The advantages of certification agency are that it acts as at rust-building

system between farmers and buyers, helps in authentication of the product, enables transparency, strengthens the position of the primary producer and helps in market promotion product.

### **Certification bodies in India**

For varied agro-climatic conditions and agricultural biodiversity, there is tremendous scope for cultivation and export of wide range of organic produce in India. Looking to its importance, Ministry of Commerce, Govt. of India has launched the Indian National Programme for organic Production (NPOP) in 2000. Which provides an institutional mechanism for the implementation of the National Standards for Organic products can be downloaded from ([www.apeda.com/organic/quality.html](http://www.apeda.com/organic/quality.html)) through a national accreditation policy and programme. This acceleration system includes certification of organic forms, products and processes as per the National Standards of Organic Products (NSOP). A National Organic Logo, 'Indian organic', communicating the authenticity and the origin of the product, will be granted on the basis of compliance with the NSOP. The National Steering Committee (NSC) functioning under the Ministry of Commerce is monitoring the programme of NPOP.

### **Accreditation agencies:**

Presently, the six accreditation agencies approved by Ministry of Commerce are authorized:

- Tea Board
- Coffee Board
- Spice Board Coconut
- Development Board
- Directorate of Cashew and Cocoa Board
- Agricultural and Processed Food Products Export Development Authority (APEDA).

### **Constrains**

- Lack of premium market price for organically grown products.
- Scanty of research works done on organic farming in plantation crops.
- As nutrients content less, so more volume needed-cost increased. Biofertilizers are not readily available.
- There is a general lack of awareness among the consumers about the quality advantage of organic products.

- Lack of infrastructure for dissemination of technology, collection, sale and export of organically grown products.

### **Future prospects**

- Indian market of organic produces has been grown with awareness of safety and quality of food.
- Organic agriculture is an economical and reliable option of profitable livelihood that is why this method has a bright scope in future.
- Research has been shown the organic farming continuously expanded throughout the world and increasing 25-30% per year from last 10 years.
- Organic agriculture has highly expanded and strengthens future prospects because of quality of organic produces are far better than chemical agriculture without any environmental, soil losses.

### **Conclusion**

- ✓ Better storage, transport and market facility for organic products.
- ✓ Setting up of more branch offices to certify organic products in the country.
- ✓ More and more areas should be brought under Organic farming either by conversion or as extension.
- ✓ Creating awareness among the public for benefits of organic farming
- ✓ Organically produced foods have higher nutrients and vitamins, safer for environment, soil and human health.

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# Chapter - 3

## Organic Production Technology of Cucumber at Cold Desert Region of Leh-Ladakh

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### Abstract

Cucumber (*Cucumis sativus*) is a widely cultivated creeping vine plant. It is one of the most important salad crops all over India but mostly in Ladakh region. It can be grown under open field and protected cultivation. It is highly rich in water content, fibers, vitamins and minerals. The organic production of cucumber is a new trend in Ladakh. In organic farming, compost is the main sources of plant nutrients. Organic matter not only

contributes to improve soil fertility and quality but enhances the production and quality of the fruit. Most of the farming practices are done by farmers based on traditional knowledge but along with local knowledge, a formal scientific approach is essential for quality production of the crop. This crop can be highly productive to small land holder and can contribute to food security if they are provided with the knowledge of cultivation practices in technical manner. Therefore, the main objective of writing this chapter is to bring awareness among farmers, academicians and students about the culture practices of cucumber, control of pathogens and suitable varieties to Ladakh region.

**Keywords:** Cucumber, Organic production, Compost, Protected cultivation, Ladakh

### **Introduction:**

Ladakh, constituting Leh and Kargil district is a high mountainous arid region of India can be characterized by a rugged topography at an average altitude of over 3000 m (Dame *et al.*, 2011). The region is characterized by extreme temperature variations, low precipitation mostly in the form of snow, high wind velocity, sparse plant density, thin atmosphere with high UV-radiation and fragile ecosystem. The temperature often drops down 0°C to - 30°C in winter. Long harsh winters reduce the cropping season to just four to five months in a year (Stobdan *et al.*, 2018). In late 1960s only five types of vegetables were grown in the region. Recently, feasibility of growing 101 types of vegetable has been demonstrated in Ladakh. The total cropped area in Leh- Ladakh is 10,223 hectare (0.2% of the total geographical area is under cultivation). The area covered under vegetables in Leh is 629 hectare out of which cucurbits vegetable are grown over 2 hectare (LAHDC Leh Report 2019).

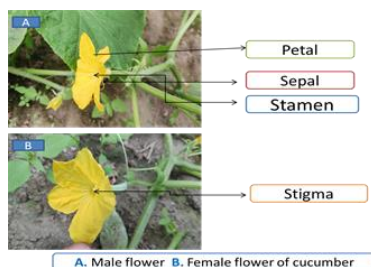
Cucumber (*Cucumis sativus*) is an important vegetable crop of cucurbitaceae family having chromosome number  $2n = 14$ . Cucumber is native of South Asia, specifically warm and humid climate of the Himalaya in North West India and probably northern Africa. India is considered to be the home of cucumber (Pal *et al.*, 2020). It is an important salad crop cultivated both in north and south and including the hilly areas of India. The immature fruit of cucumber is used as salad and for making pickles, pahari rayata and brined on commercial scale (Bairagi 2013). The fruit contains around 90- 95 % water and it delivers sodium, magnesium, potassium, sulphur, silicon, fluorides etc. in a good amount. Cucumber contains 2.6 gm carbohydrates, 0.6 gm protein, 18 mg calcium, 0.02 mg thiamin, 12 cal

energy, 0.02 mg riboflavin, 0.2 mg Iron, 10 mg vitamin C, and 0.01 mg niacin in each 100 g edible portion. Cucumber also contains secoisolariciresinol, lignans, lariciresinol and pinoresinol, which are very helpful to reduce the risk of different kinds of cancer (Pal *et al.*, 2020).

Organic farming is increasingly becoming popular because of the perceived health and environmental benefits (Zhao *et al.*, 2009). The use of compost as organic fertilizer allows improvement in fertility, in addition to being excellent soil condition, improving their physical, chemical and biological characteristics, such as retention water, aggregation, porosity, increased the cation exchange capacity, increased fertility and increased soil microbial activities (Abou-El-Hassan *et al.*, 2014).

### Botanical description:

Cucumber is an annual plant species and is found to be day neutral. Basically, it is monoecious, trailing or climbing vine with angled, hirsute or rough stems. It grows up trellises or wraps around the support with spiraling tendrils. Leaves are alternate, simple, in outline triangular-ovate. Leaf-blades are 3-7 lobed and deeply cordate at base, acute at apex. Lobes are triangular, acute at apex and dentate. The stems of the cucumber produce vines which are 4-5 angled and sparingly branched. The length of the main stem may be 2-3 m. Flowers are axillary and unisexual and occasionally hermaphrodite. With the process of evolution and human interventions, new flower types occur among cucumber like; gynoecious, hermaphrodites, gynoandromonoecious, gynomonoecious and andromonoecious. Its yellow flowers have 4-5 calyxes. Male flowers are single or borne in clusters, smaller than female flowers that have 4-5 calyxes. Female flowers are solitary on short thick pedicels of 3-5 mm long. Female flowers have 3-4 ovules. Fruits change color from pale green when young to white, yellow or brown when ripened depending on the color of fruit spines. Fruits with white spines are green and never turn yellow. Seeds are light yellow and the weight of 1000 seeds is about 20-30 g. The average occurrence of seeds per fruit is about 150 - 500 in numbers depending upon the varieties.



## **Climate and soil:**

Cucumber is a thermophilic and frost susceptible crop. It is categorised under warm-season crop grown mainly in tropical and subtropical regions. Generally long period of warmth preferably dry weather and abundant sunshine is required. This crop is also susceptible to excess humid condition which promotes foliar diseases and pest like fruit fly. So the weather conditions of Ladakh is suitable for this crop.

The effect of light intensity and day length in the process of anthesis in cucumber is much more than the impact of temperature. But, temperature has greater influence on anther dehiscence and pollen fertility. Stigma remains receptive for a very short duration. The optimum temperature favouring anthesis and dehiscence is 13°–18°C. Nevertheless, for optimum vegetative growth and yield, the temperature requirement is 18°–24°C.

Leh Ladakh soils are mostly sandy, saline in nature with the pH range of 7.5–8.5. It is necessary that soil should be fertile and well provided with organic matter. Soil moisture is the determining factor for germination of the seed and early maturity. So, it should be at least 10–15% above the permanent wilting point.

## **Varieties:**

Cucumber varieties grown in Ladakh vary from small pickling type to very large and thick. The recommended cucumber varieties for Ladakh conditions by DIHAR DRDO are Japanese Long Green, Pusa Sanyog, BSS 647 and Hilton.

**Japanese Long Green:** It is introduced from Japan. Fruits are 30-40 cm long, straight and whitish-green with dark green stripes. Flesh is light green and crisp. It is an extra early variety and first picking is possible 60-70 days grown in open area while 45-50 days under protected cultivation after planting. Average yield is 180-200 quintals per hectare.

**Pusa Sanyog:** It is a F1 hybrid (Japanese Gynoecious line × Green Long of Naples). Early and high yielding hybrid, fruit 28-30 cm long, cylindrical and dark green with yellow stripes, crisp flesh, maturity in 50-60 days under protected cultivation.

**BSS 647:** First picking is generally done after 70-80 days in open field while 50-60 days under protected cultivation after planting. Colour of the fruit is generally green with white stripes. Fruit shape: thin long. Fruit length: 18-20 cm. Average weight of the fruits is 210-240g.

**Hilton:** It is a F1 hybrid and sweet, juicy and seedless variety of

cucumber. It can be consumed without removing skin. Fruit colour: dark green with even skin tone. The average length of the fruit is 16-18cm while the average weight of the fruit varies 240-260g. Maturity 50-55 days in polyhouses.



Japanese Long Green



PusaSanyog



BSS 647



Hilton

**Land preparation:** Before sowing or transplanting, land is prepared by traditional plough, tractor or manual and then FYM is added to the soil at the time of final ploughing, to make it fertile and then leveled manually.

### **Time and method of seed Sowing**

In Ladakh region recommended seed sowing time is April–May.

**By direct seed sowing:** In Ladakh, furrow and bed sowing methods are followed. In furrow sowing, furrows are made at 1.0–1.5m apart. Usually sowing is done on the upper one- third part of the sides (inside) of furrows and vines are allowed to trail on the ground. This method is very useful in cropping season of Ladakh for an efficient and economic use of water. The hills should be made at a distance of 0.5–0.75m and the spacing between individual plants should be 45-50 cm. Considering the poor germination rate in Ladakh conditions, usually 2 seeds are sown together and finally one vine is retained, if the same is to be practiced under greenhouse conditions then sowing of one seed will suffice.

**By transplanting:** Keeping in mind the harsh environment of Ladakh seeds are sown in alkathene bags (15cm × 10cm) of 100–200 gauge and allowed to germinate under protected cover to avoid low temperature injury. The seedlings are transplanted in the month of May in open field conditions at 2-3 leafy stage. Transplants usually have straight, thick stems and disease-free leaves. This is the most suitable method of sowing according to environmental conditions.

**Seed rate:** About 2.5–3.0 kg seed is enough for sowing one hectare crop.

### **Irrigation:**

The frequency of irrigation is very important for the cucumber crop. Usually ridges or beds are light irrigated a day or 2 prior to sowing. The next irrigation is given 3-4 days after transplanting. In case of direct seed sowing, irrigation should be followed just after sowing. Crust formation of the soil should be avoided. Irrigation once in 5–6 days is necessary depending upon soil temperature and location. Over irrigation as well as water-stress conditions are harmful to cucumber. Under water-stress conditions, weight of root decreases and stressed plants leach a large amount of amino acids and sugars from roots into surrounding media during recovery. Drip irrigation is also an efficient means of irrigating cucumber. With some modifications, the drip system of irrigation saves 40% water, reducing soil salinity compared to the conventional method of irrigation.

### **Use of Manure and Biofertilizer:**

With the help of Ladakh Autonomous Hill development Council (LAHDC) and its policies, Ladakh farming society rely more on using organically developed products, organic pits for organic manure, use of night soil, leaf-litter, its ashes, FYM, Changthangi manure, mulching, goat-manure etc. Traditionally in Ladakh, night soil and cattle manure were the primary source of soil nutrients along with occasional use of goat/sheep droppings and yak dung depending on availability. Organic matter not only contribute to soil fertility and tilth by providing various macro and micro nutrients but also provides carbon and other constituents that effect soil humus content, biological activities and soil physical structure like aeration, water holding capacity and structure.

Cucumber responds well to manuring. The application of organic manure and biofertilizer not only increases the total yield but also improves the vegetative growth, flowering, fruit weight and dry-matter content. Generally well-rotten farmyard manure @ 15–20 tonnes/ha is applied at the time of land preparation.

**Table 1** Carbon, macro and micro nutrient content of manure in Ladakh region

| <b>Manures</b> | <b>Total N (%)</b> | <b>Total P (%)</b> | <b>Total K (%)</b> | <b>Carbon (%)</b> | <b>Zn (ppm)</b> | <b>Cu (ppm)</b> | <b>Fe (ppm)</b> | <b>Mn (ppm)</b> |
|----------------|--------------------|--------------------|--------------------|-------------------|-----------------|-----------------|-----------------|-----------------|
| Compost        | 1.58               | 0.50               | 68.97              | 17.71             | 0.72            | 0.16            | 19.99           | 0.72            |
| Cow Manure     | 2.30               | 0.76               | 61.97              | 36.69             | 0.71            | 0.26            | 25.95           | 2.55            |

|                  |      |      |       |       |      |      |       |      |
|------------------|------|------|-------|-------|------|------|-------|------|
| Pure             |      |      |       |       |      |      |       |      |
| Night Soil       | 0.35 | 0.35 | 71.21 | 2.12  | 1.19 | 0.35 | 31.28 | 2.10 |
| Goat Manure Pure | 2.74 | 0.70 | 70.01 | 41.27 | 0.51 | 0.16 | 8.50  | 0.70 |
| Poultry Manure   | 5.95 | 2.54 | 0.00  | 33.69 | 1.91 | 0.36 | 5.69  | 1.06 |
| Yak Manure Pure  | 2.14 | 0.70 | 69.82 | 28.86 | 0.81 | 0.19 | 18.36 | 1.76 |

Source: Raghuvanshi *et al.*, 2019

Microbial inoculation by plant growth promoting rhizobacteria (PGPR) in the soil, benefit plants by providing growth promotion and adding vital nutrients to the soil. They also reduce the chance of certain diseases. PGPR are naturally occurring soil bacteria that aggressively colonize plant roots. Various species of bacteria like *Pseudomonas*, *Azospirillum*, *Azotobacter*, *Klebsiella*, *Enterobacter*, *Alcaligenes*, *Arthrobacter*, *Burkholderia*, *Bacillus* and *Serratia* have been reported to enhance the plant growth (Joseph *et al.*, 2007).

### **Weed Management:**

Cucurbits such as cucumber are highly vulnerable to weeds in their early stage of growth. It requires a more diligent weed control program for optimum yield and quality of fruit. Weeds in a cucumber field affect crop growth, development and yield. The competition of cucumber and weeds are fierce in the vegetative development stage and the growing process. Yield is good in a weed-free environment.

Weed control should be done early in the growing period of 2 to 4 week after transplantation or direct sowing. In the first 2-3 weeks after transplanting or direct sowing, hand weeding by hoe or other tools is very effective to control weeds and break the scum layer on the upper soil surface. Hand weeding is the best technique to control weeds. It should be done before the flowering stage at an average of 2-3 times per cropping season. Hand weeding reinforces activities of microorganisms, increases nutrient absorption of the plant, limits root development in order to concentrate nutrients for the development of leaves and branches consequently increasing crop yield.

After manual removal of weeds, when the plants are 10-15 cm in height, it is important to hill-up the soil so that new roots can be produced and prevent the plant from collapsing. This process aids in maintaining air circulation in the field, breaking the scum on the soil surface and controlling weeds.

**Mulching a new technological intervention:** Nowadays, Mulching is a very commonly used method for weed control in Ladakh. Mulch is any material placed on the surface of the soil. It can be organic matter such as straw or plastic sheets. Organic matter is easily available and cheaper than plastic sheets. If straw is used, make sure that it is weed-free. Mulching over the field reduces weed by 68% and also saves 75% time in manual weeding. Temperature 10cm beneath the black polythene mulching was 4-5° higher than in non-mulching (Angmo *et al.*, 2018).

### **Staking and pruning:**

Cucumber stems, leaves and vines develop quickly in the first two weeks after transplanting. Staking and pruning can improve yield and fruit size as well as reduce fruit rot incidence. The process also makes it more convenient for crop care and harvesting. Plants staked and pruned give early harvest.

Staking should be done when the plant is about 30 cm high. Cucumber stem grows very fast and vines elongate rapidly. Thus vines should be tied regularly, better every 2- 3 days. In Ladakh conditions, poles and stakes made of willow or poplar trees are used or any sturdy material like PVC/ iron pipes can be used to provide support and keep the fruit and foliage off the ground

Cucumber develops many side branches that are not productive. To improve yield, remove lateral branches until the runner reaches the top of the trellis. Leave 4-6 laterals and cut the tip of the main runner to induce early cropping. Removal of lateral branches in the first 10 nodes has a positive effect on total yield. Without pruning, most of the female flowers occur between the 10th and 40th nodes, or at a height of 0.5-2 m.

**Plant Protection:** Due to dry environmental conditions of Ladakh, insect pest and disease infestation is rarely reported on this crop. But, sometimes due to alteration in weather conditions, some insect pest/diseases have been reported on this crop.

### **Insect:**

1. **Cucumber beetles** (*Acalymma vittatum* and *Diabrotica undecimpunctata*): The striped cucumber beetle (*Acalymma vittatum*) and the spotted cucumber beetle (*Diabrotica undecimpunctata*) are the most common insect pests of cucumber crops.

### **Symptoms:**

These beetles cause damage to the plants in at least three ways. First, they enter the soil through cracks and feed on emerging seedlings below the

soil surface; as a result, the plant is either killed or may have stunted growth. Adult beetles feeding on cotyledons and young leaves can cause reduction in crop stand and delay growth. They feed on flowers and pollen in the later growth stage during summer and reduce fruit set. Second, they transmit diseases like bacterial wilt (*Erwinia tracheiphila*). Third, the adults feed on fruits and cause scars on the fruit surface, followed by lowering marketable quality of fruits.

### **Management:**

1. Crop rotation can also help in reducing the incidence of cucumber beetles.
  2. Use of pheromone trap to attract the cucumber beetle.
  3. Plastic or organic mulches can prevent cucumber beetles from laying eggs in the field near plant stems
  4. Use of botanical extract like Pyrethrum and azadirachtin oil.
  5. Sprays with entomopathogenic nematodes can lead to declines in soil dwelling cucumber beetle larvae.
  6. Use of natural enemies that attack cucumber beetles include parasitoids (tachinid flies) and Predators like (wolf spiders, ground beetles).
2. **Aphids** (*Myzus persicae* and *Aphis gossypii*): Aphids are small about 3 mm long, soft-bodied, pear-shaped insects with long legs and antennae. They are pale green, yellow, brown, red, or black in color.

### **Symptoms:**

The first sign of aphid damage is a downward curling and crinkling of the leaves. Aphids are often found on lower leaves, soft-growing tips, flower buds, and flowers. Aphids pierce the plant tissue and extract sap, which causes a variety of symptoms, including reduced plant growth and vigor, mottling, yellowing, browning, curling, or wilting of leaves, which result in low yields and sometimes death of plant.

### **Management:**

1. Use of yellow sticky traps would be helpful in detecting aphids 2–3 weeks prior to planting.
2. Reflective polyethylene and biodegradable synthetic latex spray mulches were found effective for the management of aphids.
3. Use of neem oil @ 5ml/liter every 7 days from 3-true leaf-stage until beginning of flowering stage.

4. Use of some common aphid predators includes species of lady beetles and their larvae (*Harmonia axyridis*, *Hippodamia convergens* and *Coleomegilla maculata*).
3. **Whitefly (*Bemisia tabaci*):** These are small insects about 1–1.5 mm long. The body and wings of adult flies are covered with fine whitish powdery wax.

### Symptoms:

The silver leaf whitefly gets its name because it injects a toxin into the plant that causes whitening of the undersurface of newly emerging leaves. Damage may be more severe on younger plants as compared to plants about to harvest. It can affect the crop directly by its feeding and by acting as a vector of viruses. They suck sap from the phloem and excrete honeydew (a sugar-rich substrate) that promotes the growth of sooty mold (*Capnodium* spp.) on leaves and economic plant parts. They also damage the plant by transmitting viruses.

### Management:

1. Yellow sticky traps can be used to detect and monitor the activity of whiteflies in the field.
2. The cultural control methods include mulching, crop rotation, floating row covers, cover crops, non infested transplants, and good field sanitation to prevent the buildup of whiteflies.
3. Destroy old crop residues.
4. Use of neem oil @ 5ml/liter every 7 days from 3-true leaf-stage until beginning of flowering stage.
5. Use of Biological control agents such as *Encarsia formosa*, *Encarsia luteola* and *Eretmocerus californicus*, predator like green lacewing (*Chrysopa* sp.) or lady beetles (*Coccinellidae*);

### Diseases:

1. **Damping off** – (*Fusarium*, *Rhizoctonia*, *Pythium*, *Phytophthora* sp.)

### Symptoms:

Damping-off may occur when seedling death is preceded by cotyledon and leaf chlorosis. In seedlings, a watery rot develops in the taproot and hypocotyl at or near the soil line. Mature plants show symptoms of root and crown rot. Initially, feeder roots are depleted. After that, brown lesions, 0.5-2.0 cm long, develop on lateral roots. Necrosis soon follows, as the symptoms gradually move outward, toward the runner tips. Sudden wilt is

another symptom, healthy-appearing plants suddenly collapse during the heat of the day.

**Management:**

1. Remove and destroy crop left-overs as these may contain spores of damping-off fungi and other pathogens.
2. Planting of cucumber on raised beds to allow for maximum water drainage after each irrigation.
3. Soil sterilization should be done before sowing.
4. Do not apply high doses of nitrogen.
5. Crop rotation should be applied.
6. Use vigorous seed or seedlings.
7. Application of *Trichoderma spp.*

**2. Powdery mildew – (*Erysiphe cichoracearum*):**

**Symptoms:**

Whitish, talcum-like, powdery fungal growth develops on both leaf surfaces and on petioles and stems. Symptoms usually develop first on older leaves, on shaded lower leaves, and on abaxial leaf surfaces. Older, fruit-bearing plants are affected first. Infected leaves usually wither and die, and plants senesce prematurely. Fruit infection occurs rarely in watermelon and cucumber.

**Management:**

1. Use resistant cultivars.
2. Destruction of host plant belonging to the cucurbit family.
3. Pruning diseased leaves to prevent disease spread to other leaves.
4. Where the number of plants is small, use milk: normal strength milk diluted in water (1:10).

**3. Cucumber mosaic virus – (*Cucumber mosaic virus*):**

**Symptoms:**

CMV causes severe plant stunting; prominent foliar yellow mosaic, malformation, and drastic reduction of leaf size and stem internodes. In early stages of growth, systemic symptoms consist of prominent downward leaf curling, mosaic and reduced leaf size. Flowers of severely affected plants may have prominent abnormalities and greenish petals. Infected fruits become distorted and often discolored and usually remain small. In severe affected fruits, seed production is negligible.

**Management:**

1. Timely proper identification and elimination of disease source.
2. Use resistant varieties.
3. Regularly crop rotation should be done.
4. Seeds should be treated before sowing, dipping of seed in hot water of 55°C for 60 minutes.
5. To kill the vector like aphids is an effective control method.
6. If initially symptom is seen on one or some plant then uproot and burn virus infected plants.

**Harvesting:**

Fruits of cucumber attain edible maturity within a week from anthesis of female flowers, though variation for edible maturity exists among its varieties. Picking of fruits at right edible stage depends upon individual varieties and marketing requirement. In salad or slicing cucumber, dark green skin is preferred. White spine colour is also a useful indication for their edible maturity. Further, over mature fruits show carpel separation in transverse section of the fruits. Usually 4-5 harvesting depending upon the varieties is done.

For seed purpose, pale-yellow and golden-yellow (mature fruit colour) cucumbers should be harvested in white and black spine varieties respectively. Its yield varies according to system of cultivation, cultivar, season and other factors.

**Yield:** Cucumber yield varies according to system of cultivation, cultivar, season and other factors. About 100-150 q/ha is obtained from open conditions by using monoecious variety. This yield could be doubled by using gynoeceious variety. Under greenhouse conditions about 250-300 q/ha yield is obtained using gynoeceious hybrids.

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# Chapter - 4

## Ladakh: Organic Cultivation Practices of Tomato (*Lycopersicon esculentum*)

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### Abstract:

Tomato is one of the most important food crop having diverse uses. Now a days there is a high demand of organic produce in the market, therefore, organic tomatoes have an excellent prospect for local market sales. These are highly demanded by consumers seeking for organic produce for health purposes. As compared to inorganic tomatoes the concentrations of vitamin -C in organic tomatoes are found up to 57% higher while phenolic compounds are observed in double quantities in ripe fruits. These phyto-nutrients help the body to fight with oxidative stress - a form of chemical damage linked to chronic conditions such as heart disease, cancer and dementia etc. However, the main idea behind organic farming is ‘zero

impact' on the environment, to protect natural resources and produce safe and healthy crops. The organically grown crop can be made highly productive to ensure food and nutrition security if the growers are provided with the knowledge of effective and green cultivation practices in technical manner. Therefore, the main objective of writing this chapter is to bring awareness among farmers, academicians and suggest students about the culture practices of tomato, control of pathogens and suitable varieties to grown in Ladakh region.

**Keyword:** Tomato, Organic production, compost, Ladakh

## **Introduction:**

Ladakh, a high altitude region, is well known for its extreme environment and scenic beauty with a wide range of mountains, glaciers, cold deserts and hot springs. Due to its geographical location and long-harsh weather condition, the cropping season is limited to four to five months a year (Stobdan *et al.*, 2018). In late 1960s, only five types of vegetables were grown in the region, however, recent studies have shown that it is possible to grow 101 different types of vegetables.

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetables grown worldwide due to its wider adaptability and multifarious uses. Its cultivation is also done as an important vegetable crop in Leh - Ladakh area of Trans Himalaya (Sepat *et al.*, 2012). It belongs to the family *Solanaceae*, which also includes important crop, such as potato, tobacco, peppers and brinjal. Common names for the tomato are: tomate (Spain, France), tomat (Indonesia), tomato (India), tomati (West Africa), jitomate (Mexico) and pomodoro (Italy) (Dam *et al.*, 2005).

It has its origin in the South American Andes. The Spanish conquistadors brought the cultivated tomato to the Europe in the sixteenth century and later on it was introduced from Europe to southern and eastern Asia, Africa and the Middle East. Recently, wild tomato has been dispersed to other parts of South America and Mexico (Rambabu, *et al.*, 2019).

Tomatoes are important not only from consumption view point because of the large amount consumed, but also because of their higher health and nutritional contributions to humans (Preedy and Watson, 2008). It can be consumed fresh as salads or cooked in sauces, soup and meat or fish dishes. An ample amount of minerals, vitamins, essential amino acids, sugars and dietary fibers are found in tomatoes (Caputo *et al.*, 2004 and Hernandez *et al.*, 2007). Not only tomatoes but its products (purées, juices, ketchup, canned and dried tomatoes) are rich in antioxidant and appraised to be a

source of carotenoids in particular lycopene and phenolic compounds. They are low in fat and calories, as well as cholesterol-free (Ilahy *et al.*, 2011 and Pinela *et al.*, 2012). Including the tomatoes in our daily diet lowers the risk of certain cardiovascular diseases and certain types of cancer, such as cancers of prostate, lung and stomach (Canene-Adams *et al.*, 2005). A key bioactive phyto-compound of tomato, lycopene, being a potent antioxidant, is currently marketed as a fortified nutritional supplement (Preedy and Watson, 2008).

Organic farming is not a new concept to Indian agriculture community. Organic farming in multiplex forms are being successfully practiced in variant climate, explicitly in rain fed, tribal, mountains and hill areas of the country (Baby, 2013). Recently, organic farming is becoming bliss because of the noted health and environmental benefits (Zhao *et al.*, 2009). The use of compost as organic fertilizer allows improvement of soil fertility, in addition to being excellent soil conditioner, it improves their physical, chemical and biological characteristics, such as water retaining capacity, aggregation, porosity, cation exchange capacity, fertility and soil microbial activities *etc* (Abou-El-Hassan *et al.*, 2014).

Organic production methods by definition do not guarantee a higher quality product (Zoran *et al.*, 2014). In terms of quality, some studies report better taste, higher vitamin C contents and higher levels of other quality related compounds for organically grown products (Caris-Veyrat *et al.*, 2004).

### **Botanical Description:**

Although tomato is a perennial herbaceous plant but it is often grown as an annual crop even if biennial and perennial forms exist. The approx height of the plant varies from 2 to 4 m. The stem is solid, coarse, hairy and glandular. Leaves are spirally arranged, having length 15-50 cm and width 10-30 cm. Ovate to oblong leaflets, covered with glandular hairs are present. Small pinnates appear between larger leaflets. Inflorescence is clustered and produces 6-12 flowers. Petiole is 3-6 cm. Growth habit of stem ranges between erect and prostrate. It grows to a height of 2-4 m. The stem is solid, coarse, hairy and glandular. It has a vigorous tap root system that grows to a depth of 50 cm or more. The main root produces dense lateral and adventitious roots. Flowers are bisexual, regular and 1.5-2 cm in diameter. They grow opposite or between leaves. Calyx tube is short and hairy, sepals are persistent. Usually 6 petals up to 1 cm in length yellow and reflexed when mature. 6 stamens, anthers are bright yellow in colour surrounding the

style with an elongated sterile tip. Ovary is superior and with 2-9 compartments. Mostly self- pollinated but partially cross-pollinated. Bees and bumblebees are the most important pollinators. Fruits are fleshy berry, globular to oblate in shape and 2-15 cm in diameter. The immature fruit is green and hairy. Color of ripe fruits range from yellow or orange to red. It is usually round, smooth or furrowed. Seeds are numerous, kidney or pear shaped, hairy, light brown 3-5 mm long and 2-4 mm wide. The embryo is coiled up in the endosperm. Approximate weight of 1000 seeds is 3.0 – 3.5 g (Dam *et al.*, 2005 and Knapp and Peralta, 2016).

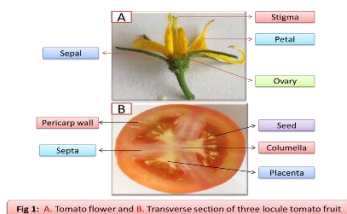


**Fig 1:** A. Tomato flower and B. Transverse section of three-locule tomato fruit

**Climate:** Tomato is cultivated in tropical and temperate climates in open field or under greenhouse. Protected cultivation is often used for large-scale production. Tomato requires a relatively warm, cool and dry climate for high yield and quality. Hence the weather conditions of cold- arid region of Ladakh are suitable for this crop. The optimum temperature for most varieties lies between 21°C - 24 °C. The plants can survive a range of temperatures (10°C - 30 °C), but the plant tissues are damaged below 10 °C and above 38 °C. Temperatures above 31°C reduce the rate of flower formation; affect fertilization, plant development and fruit ripening (Garza and Molina, 2008).

**Soil:** Tomato is moderately tolerant to a wide range of pH, but grows well in soils with a pH of 5.8– 8.5 with adequate nutrient supply and availability (Dam *et al.*, 2005). Leh-Ladakh soils are mostly sandy, saline in nature with a pH range of 7.5–8.5. It is necessary that soil should be fertile and provided with well decomposed organic matter. Soil moisture is the determining factor for germination of the seed and early maturity.

**Choice of variety:** Choice of varieties depends upon the local conditions and the purpose. Selection criteria are based on climatic conditions, type of fruit, shape of plant, vitality and resistance to pests and diseases. In Ladakh, Defence Institute of High Altitude Research (DIHAR) has grown various varieties like Tolstoy, Roma, Sioux, Pusa Divya, Best of All and Marglobe *etc.* but Tolstoy and Roma variety performs best under the local conditions.

**Tolstoy:** Tolstoy an F1 hybrid, developed by Dutch breeders of Bejo Zaden, is an indeterminate type intended for cultivation in the open and under controlled condition. It has a strong stem and powerful roots, deciduous shrubs, short internodes and long branches. The fruit ripening time period is about four months. Average fruit weight is approximately 100-120 g. It is resistant to late blight, fusarium wilt, leaf mosaic virus and verticillium wilt. It is suitable for fresh consumption and processing.

**Roma:** This is a determinate variety is released from IARI, New Delhi. Fruits are elliptical in shape with yellow, thick stemmed and red when fully ripe. It is a prolific bearer with good foliage cover. These have few seeds and are good for canning and sauce preparation. Its average fruit weight is about 60-70 g and has resistant to verticillium and fusarium wilt.



Tolstoy



Roma

**Land preparation:** Ploughing is necessary to prepare the land for a tomato crop. It improves the structure and water holding capacity of the soil. In Ladakh, before sowing or transplanting, the land is prepared by cultivator 2-3 times and then compost is added to the soil at the time of final ploughing, to make it fertile and then leveled manually. It also helps to reduce soil-borne pests and diseases by exposing the soil to the sun.

**Seedling:** Transplantation method is generally preferred for tomato in order to obtain vigorous, healthy and uniform growth of plants. Keeping in mind the harsh environment of Ladakh, seeds are sown in green house or poly house or trench during the last week of March to the first week of April.

**Nursery preparation:** Tomato seeds are sown on nursery beds. In Ladakh, the seedbeds are flat and the length depends upon the number of seedlings required. The well decomposed farmyard manure is added to the nursery. Lines are drawn 10-15 cm apart, over the length of the seedbed. Seeds are sown at a depth of 1.5-2 cm and then covered with a fine layer of soil followed by light irrigation. To ensure the sufficient moisture for germination, the seedbeds are watered twice a week. For germination of healthy seedlings, plenty of light is required. About 350 - 400 g (open pollinated variety) and 100 - 150 g (hybrid variety) seeds are sown 250 m<sup>2</sup> of nursery area which is sufficient for raising seedlings for one hectare area.

**Transplanting and spacing:** Generally in Ladakh region mulching is preferred. Before transplanting, mulch can be placed on the ground and hole should be done at spacing of 50 cm × 50 cm or 60 cm × 45 cm distance. Seedlings are transplanted to the main field 30-35 days after sowing. Length of seedlings suitable for transplanting should be between kept 15 cm-25 cm with 3-5 true leaves. While lifting the seedlings, a large clump of soil is attached to the roots to prevent them from being damaged. Transplanting should preferably be done in the afternoon or on a cloudy day to reduce the transplanting shock. Row to row and plant to plant distance of (1.0 m x 0.5 m) is suitable for bush type varieties (determinate), (0.75 m x 0.5 m) for semi-bush type (semi-determinate) and (0.70 m x 0.5 m) for tall type (indeterminate).

### **Irrigation:**

The frequency of irrigation is very important for the tomato crop especially during flowering and fruit formation stage therefore water stress should be avoided during this period. Irrigation should be done immediately after transplanting of seedling. The next irrigation is given 4–5 days after transplanting. Crust formation in the soil should be avoided. Irrigating once in 6–7 days is necessary depending upon the soil temperature and location. About 100 mm of water per week is needed under hot and dry periods. Over irrigation as well as water-stress conditions both are harmful to tomato plant.

**Use of organic manure:** With the help of Ladakh Autonomous Hill development Council (LAHDC) and its policies, Ladakh farming society rely more on using organically developed products, organic pits for organic manure, use of night soil, leaf-litter, its ashes, FYM, Changthangi manure, mulching, goat-manure etc. Traditionally in Ladakh, night soil and cattle manure were the primary source of soil nutrients along with occasional use of goat/sheep droppings and yak dung depending on availability. Organic matter not only contributes to soil fertility and tilth by providing various macro and micro nutrients but also provides carbon and other constituents that effect soil humus content, biological activities and soil physical structure like aeration and water holding capacity (**Raghuvanshi *et al.*, 2019**).

Tomato responds well to manuring. Generally well-rotten farmyard manure @ 15-20 tones/ha is applied at the time of land preparation.

**Table 1:** Carbon, macro and micro nutrient content of manure in Ladakh region

| Manures | Total N (%) | Total P (%) | Total K (%) | Carbon (%) | Zn (ppm) | Cu (ppm) | Fe (ppm) | Mn (ppm) |
|---------|-------------|-------------|-------------|------------|----------|----------|----------|----------|
| Compost | 1.58        | 0.50        | 68.97       | 17.71      | 0.72     | 0.16     | 19.99    | 0.72     |

|                  |      |      |       |       |      |      |       |      |
|------------------|------|------|-------|-------|------|------|-------|------|
| Cow Manure Pure  | 2.30 | 0.76 | 61.97 | 36.69 | 0.71 | 0.26 | 25.95 | 2.55 |
| Night Soil       | 0.35 | 0.35 | 71.21 | 2.12  | 1.19 | 0.35 | 31.28 | 2.10 |
| Goat Manure Pure | 2.74 | 0.70 | 70.01 | 41.27 | 0.51 | 0.16 | 8.50  | 0.70 |
| Poultry Manure   | 5.95 | 2.54 | 0.00  | 33.69 | 1.91 | 0.36 | 5.69  | 1.06 |
| Yak Manure Pure  | 2.14 | 0.70 | 69.82 | 28.86 | 0.81 | 0.19 | 18.36 | 1.76 |

Source: Raghuvanshi *et al.*, 2019

**Weed Management:** Weeds compete with the tomato plants for light, water, nutrients and space. Sometimes they provide shelter for organisms that cause tomato diseases, such as Tomato Yellow leaf curl virus (TYLCV), and reduce the yield. Weed control should be done early in the growing period of 2 to 4 weeks after transplanting. In the first 2-3 weeks after transplanting, hand weeding used hoe or other tools is very effective to control weeds and to break the scum layer above the soil surface.

Nowadays, mulching is a very commonly used method for weed control in Ladakh. Mulch is any material placed on the surface of the soil. It can be organic matter such as straw or synthetic inorganic like plastic sheets.

**Pruning:** Pruning is important for tomatoes, especially for thick bushy and indeterminate varieties grown under protected cultivation. It improves the light penetration and air circulation. The need for pruning depends on the type of plant and the size and quality of the fruit. If plants are not pruned, they will grow randomly and fruits will be developed smaller in size.

**Staking:** For greatest yield, this crop requires some means of support and trellising. Lifting and supporting the plants provide better air circulation to help prevent diseases and pest and makes it easier to harvest the fruit during their growth. Mostly in protected cultivation, tomato plants (tall type) can be tied to sticks to support the stems. The plants are tied loosely to the sticks and retied regularly as they grow. Support sticks should be put in place before transplanting, avoiding any damage to the plant roots.

**Plant Protection:** Due to the harsh environmental conditions of Ladakh, insect pest and disease infestation is rarely observed on the crops here. But, sometimes due to alteration in weather conditions, some insect pest/diseases have been reported in this crop. It crop is being very susceptible to frost condition so it is very important to prevent it from adverse conditions.

## **Insect:**

1. **Whitefly (*Bemisia tabaci*):** These are small insects about 1–1.5 mm long. The body and wings of adult flies are covered with fine whitish powdery wax (Fig. 2 A).

**Symptoms:** The silver leaf whitefly gets its name because it injects a toxin into the plant that causes whitening of the undersurface of newly emerging leaves. Damage may be more severe on young plants. It can affect the crop directly by feeding and also by acting as a vector of viruses. It sucks sap from the phloem and excretes honeydew (a sugar-rich substrate) that promotes the growth of sooty mold (*Capnodium* spp.) on leaves and economic plant parts. They also damage the plant by transmitting viruses.

## **Management:**

1. Yellow sticky traps can be used to detect and monitor the activity of whiteflies in the field.
  2. The cultural control methods include mulching, crop rotation, floating row covers, cover crops, non infested transplants, and good field sanitation to prevent the buildup of whiteflies.
  3. Destruction of old crop residues.
  4. Use of neem oil @ 5 ml/liter at an interval of 7 days from 3-true leaf-stage until the beginning of flowering stage.
  5. Use of biological control agents such as *Encarsia formosa*, *Encarsia luteola* and *Eretmocerus californicus*, predators like green lacewing (*Chrysopa* sp.) or lady beetles (*Coccinellidae*);
2. **Aphids (*Myzus persicae* and *Aphis gossypii*):** Aphids are small about 3 mm long, soft-bodied, pear-shaped insects with long legs and antennae. They are pale green, yellow, brown, red, or black in color (Fig. 2 B).

**Symptoms:** The first sign of aphid damage is a downward curling and crinkling of the leaves. Aphids are often found on lower leaves, soft-growing tips, flower buds, and flowers. Aphids pierce the plant tissue and extract sap, which causes a variety of symptoms, including reduced plant growth and vigor, mottling, yellowing, browning, curling, or wilting of leaves, which resulting in low yields and sometimes death of the plants.

## **Management:**

1. Use of yellow sticky traps would be helpful in detecting aphids 2–3 weeks prior to planting.
2. Reflective polyethylene and biodegradable synthetic latex spray

mulches were found effective for the management of aphids.

3. Use of neem oil @ 5 ml/liter at an interval of 7 days from 3-true leaf-stage until beginning of flowering stage.
4. Use of some common aphid predators include species of lady beetles and their larvae (*Harmonia axyridis*, *Hippodamia convergens* and *Coleomegilla maculata*).



**Fig 2: A. Whitefly (*Bemisia tabaci*) and B. Aphid (*Aphis gossypii*)**

### Diseases:

1. **Damping off** (*Pythium* sp., *Rhizoctonia* sp. and *Fusarium* sp.): Damping off typically occurs when old seed is planted in cold, wet soil and it is increased further by poor soil drainage.

**Symptoms:** Pre and post emergence death of seedlings in nursery beds. In pre-emergence phase, seedlings are killed just before their emergence to soil surface. Post-emergence phase is characterized by the infection of collar region of young, juvenile tissues at the ground level. Young radical and plumule gets killed leading to complete rotting of the seedlings.

### Management:

1. Removal and destruction of crop left-overs as these may contain spores of damping-off fungi and other pathogens.
  2. Planting of tomato on raised beds to allow for maximum water drainage after each irrigation.
  3. Soil sterilization should be done before sowing.
  4. Crop rotation should be followed.
  5. Use vigorous seed or seedlings.
  6. Application of *Trichoderma* spp. @ 4.0 g/ha.
2. **Fruit rot:** Fruit are mostly affected by *Colletotrichum* and *Rhizoctonia* spp.

**Symptoms:** Initially, small, slightly sunken, water-soaked, circular spots appear which turn darker than surrounding tissue. Spots become depressed, about 12 mm in width. *Rhizoctonia* can infect fruits, touching the soil. Green fruit also display symptoms as small, circular brown spots with definite concentric rings.

**Management:**

1. Proper water management to minimize excess moisture on the plants.
  2. Removal and destruction of the affected fruits.
  3. Use of *Trichoderma hamatum* and *Gliocladium virens* (Lewis *et al.*, 1990).
- 3. Tomato leaf curl:** It is a viral disease of tomato and is more serious all over India. It is transmitted by white fly.

**Symptoms:** Plants show chlorosis, reduced leaflet size, stunted growth with downward rolling and crinkling of leaves. Flowering and fruit setting is drastically reduced. It can be managed by adopting remedial measures but cannot be controlled once it appears.

**Management:**

1. The infected plants should be rouged out and destroyed.
  2. Use of neem oil @ 5 ml/liter for control of vector every 7 days from 3-true leaf-stage until beginning of flowering stage.
  3. Use of natural enemies for controlling virus population, such as *Encarsia formosa*, *Encarsia luteola* and *Eretmocerus californicus*, predator like green lacewing (*Chrysopa* sp.) or lady beetles (*Coccinellidae*)
- 4. Sunburn or Sunscald:** It is the physiological disorder of tomato. Sunscald occurs on fruits exposed to the sun during periods of extreme heat.

**Symptoms:** Initial symptoms are shiny white or yellow areas on the sides of the fruit exposed to the sun. Later, the affected tissue dries out and collapses, forming slightly sunken, wrinkled areas. Secondary organisms invade the affected areas causing the fruit to rot.

**Management:**

1. This can be prevented by providing more shade during fruit ripening by planting trees, or by judicious intercropping.
2. Sunburn is more frequent on un-staked tomatoes.

**Harvesting:** According to Dam *et al.*, 2005, tomato can be classified into four stages of maturity. Stage 1: Seed are white in color (immature) and can be cut when the fruit is sliced. There is no juice inside the tomato. Stage 2: Seeds have a tan color (mature) and some juice is present. Stage 3: Seeds are pushed aside when cut. Internally the fruit is green in color. Stage 4: Juice becomes red in color. Fruits that are harvested at the first stage of maturity will ripen into poor-quality tomatoes. Fruits these harvested at third and fourth stages of maturity will ripen into good-quality tomato.

Depending upon the varieties, the crop is ready for first harvesting usually 3 to 4 months after transplanting. Since all the fruits do not mature at the same time, they are harvested multiple times at an interval of 6-7 days. During it life cycle, generally 4-5 picking can be obtained from single plant.

**Yield:** Tomato yield varies according to system of cultivation, cultivar, season and other factors. On an average the yield varies from 7 kg per plant, about 500-600 quintal/hectare under green house conditions and 250-300 quintal/hectare under open conditions.

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# Chapter - 5

## Impact of Organic Farming on Soil Health

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### Abstract

The need of sustainable agriculture is universal and way to achieving it has been defined through intensive empirical research. Several indicators for the sustainability of agricultural systems have also been developed. Use of synthetic fertilizers and their effects on crop production, soil health, environmental quality, biodiversity conservation and self-reliance of farming system have been discussed in the context of agricultural sustainability. Degradation of soil fertility due to use of synthetic agro-inputs is considered as one of the most important factors affecting sustainability of agricultural systems. Presence of soil organic matter and soil microbial population are primarily useful indicators of soil health and productivity of both crops and livestock. A long-term integrated approach will be an appropriate solution for standardizing fertility management in organic farming considering the complex interactions among different components of this system. A comprehensive and systematic review on different qualitative and quantitative changes of soil health parameters for improved nutrient management supports these observations

### Introduction

Organic Agriculture Movement the primary objective of organic farming is the sustainable crop production for maintaining long-term soil fertility in harmony with natural systems. Therefore, to sustain the agricultural productivity and environmental quality soil health management. Soil health is defined as the continued capacity of soil to function as a vital living system. The biological elements are key to ecosystem function within

land use boundaries (Doran and Zeiss 2000, Karlen *et al.* 2001) and are able to sustain not only biological productivity of soil but also maintain the quality of surrounding environment. Soil health is defined as the capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans. Because soil health has a qualitative nature, farmers and scientists across the world have developed their own set of indicators of soil health such as color, tilth, drainage, presence and diversity of macro fauna and weeds, and crop yield. Unfortunately, without a unified definition of soil health, it can be difficult to coalesce soil health trends from disparate soil studies. However, in 2017, the Soil Health Institute announced Tier 1 soil health indicators in an effort to give scientists and farmers a common set of metrics to measure and monitor soil health through time. Those indicators included a combination of chemical, physical, and biological metrics

Healthy soils are essential for resilient crop production and supporting ecosystem. They positively contribute to soil water retention, support a diversity of organisms vital to decomposition and nutrient cycling, provide crops with essential nutrients and can maintain soil health and carbon stores in soil, to contributing global climate change. The growing demands for food, feed, fiber, and fuel if we do not maintain soil health. The life in the soil provides the foundation for successful farming, and for all terrestrial plant, animal, and human life on Earth. A diverse community of soil bacteria, fungi, protozoa, worms, arthropods, and other organisms, commonly known as the soil food web, converts fresh residues into soil organic matter (SOM), and plays a central role in each of the soil functions considered essential for agricultural production. Unfortunately, soils in the India are being degraded by unsustainable agricultural practices. Techniques used by organic farmers can help stop soil health degradation, or even restore soil health in previously degraded soils, because they replenish soil organic carbon and preserve underground biodiversity. However, the specific impacts of organic practices on soil health are not well understood.

Soil health comparing organic and conventional systems consistently show the benefits of organic farming, but rarely compare strategies within organic systems to understand where these benefits arise, or how they can be maximized. This report looks at past research on the benefits of organic farming to soil health and climate change mitigation. International Federation of Organic Agriculture Movements (IFOAM), a nongovernmental organization internationally networking and promoting organic agriculture, has established guidelines that have been widely adopted by the organic community for organic production and processing. Organic

farming system is based on the management of soil organic matter, which in turn maintains the physical, chemical, and biological properties of soil (Ramesh *et al.* 2005 and Stockdale *et al.* 2001). It is now a well-established fact that organically managed soil exhibits greater soil organic carbon and total nitrogen; lower nitrate leaching (Drinkwater *et al.* 1998) and biological soil quality (Lokanath *et al.* 2006 and Yakovchenko *et al.*1996) than conventionally managed soil. Long-term studies have shown higher soil microbial biomass carbon under organic than conventional management (Glover *et al.*2000). From the environmental perspective also, organic practices were claimed to have improved soil ecosystem quality 28 and long-term farm-level sustainability Ikemura and Shukla 2009.

The popularity of organic agriculture partly stems from the increasing awareness about negative effects of intensive, non organic agriculture, including human health risks due to pesticides and a limited long-term sustainability due to, for example, the development of resistances to pesticides. A total of 82 countries had 43.1 million hectares of agricultural land under organic certification in 2013, which constitutes an almost fourfold increase compared to that in 1999. This acreage accounted for approximately 1% of the total share of agricultural land worldwide (Willer and Lernoud, 2015). The following key aspects of the environmental impact of organic agriculture are addressed in this article compared to nonorganic agriculture:

1. Pest and disease control
2. Crop pollination
3. Organic matter decomposition
4. Soil quality
5. Ground and surface water
6. Climate and air and
7. Food production and quality

|                        | Soil Functions                                        | Some Key Organisms                                        |
|------------------------|-------------------------------------------------------|-----------------------------------------------------------|
| <b>CROP PRODUCTION</b> |                                                       |                                                           |
| Plant nutrition        | 1Retains and recycles nutrients from organic residues | Decomposer bacteria and fungi, earthworms, arthropods*    |
|                        | 2Delivers nutrients to plants.                        | Protozoa, nematodes, N fixing bacteria, mycorrhizal fungi |

|                                                |                                                                                      |                                                                                                    |
|------------------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Plant-available moisture Drainage and aeration | Maintains SOM, aggregation (tilth), network of small and large pores, deep channels. | Bacteria (glues), fungi (mycelia), earthworms, arthropods, plant roots, (pores, channels, exudates |
|                                                | Deters plant pathogens, nematode and other pests.                                    | Pathogen antagonists, predators and parasites of pests                                             |
|                                                | Enhances plant disease and pest resilience                                           | Microbial symbionts that induce systemic resistance (ISR)                                          |
| <b>ECOSYSTEM SERVICES</b>                      |                                                                                      |                                                                                                    |
| Water quality                                  | Minimizes leaching and runoff. Retains nutrients.                                    | Plant roots and cover microbes that immobilize nutrients                                           |
| Detoxification                                 | Attenuates plant, animal, and human pathogens. Binds or destroys toxins.             | Dung beetles, microbes that degrade organic wastes and pesticides, or bind heavy metals            |
| Carbon sequestration                           | Builds stable soil organic matter (SOM).                                             | lant roots, fungi, bacteria, deepburrowing earthworms                                              |
| <b>SOIL SELF-MAINTENANCE</b>                   |                                                                                      |                                                                                                    |
| Stability against erosion                      | Protects soil surface, maintains soil aggregation.                                   | Plant cover and roots, fungi (hyphae), bacteria (glues)                                            |
| Resilience and tilth                           | Restores structure after tillage, grazing, traffic, or downpour.                     | Plant roots, earthworms, arthropods, fungi                                                         |
| Active and stable SOM                          | Digests manure and plant residues into SOM.                                          | Decomposer bacteria and fungi, earthworms, arthropods                                              |
| Food and habitat for soil life                 | Builds active SOM, maintains large and small pore spaces                             | Plant roots (exudates), fungi, bacteria, earthworms, arthropods                                    |

**Organic Matter Decomposition** - Nutrient cycling is primarily driven by microorganisms, but soil fauna also contributes to the breakdown of organic matter in agricultural fields. Certain agricultural practices that are commonly, but not exclusively, used in organic agriculture utilize litter decomposition services directly to improve nutrient availability to crop plants (e.g. adding crop residues or cultivating legumes in the crop rotation). Empirical studies on decomposition services indicate that both higher and lower rates of litter decomposition can be observed in organic compared to nonorganic agriculture. A higher decomposition rate is usually explained by larger populations of soil organisms under organic agriculture (Tuck *et al.* 2014). Lower rates are explained by the higher N content and therefore more rapid decomposition of plant litter under the application of synthetic fertilizers in nonorganic agriculture (Scheller and Joergensen, 2008).

**Table 1:** Some key functional groups of soil organisms

| Functional group               | Energy and carbon source                 | Organisms                                                                             |
|--------------------------------|------------------------------------------|---------------------------------------------------------------------------------------|
| Photosynthesizers              | Sunlight + atmospheric CO <sub>2</sub> . | Plants, algae, cyanobacteria                                                          |
| Chemo-autotrophs*              | Inorganic compounds + CO <sub>2</sub>    | Specialized archaea and bacteria                                                      |
| Decomposers                    | Organic residues                         | Bacteria, fungi                                                                       |
| Grazers                        | Bacteria, archaea, fungi                 | Protozoa, nematodes                                                                   |
| Predators                      | Various soil organisms                   | Nematodes, arthropods                                                                 |
| Shredders                      | Organic residues + microbes              | Micro-arthropods                                                                      |
| Ecosystem engineers            | Organic residues + organisms             | Earthworms, termites, ants, dung beetles                                              |
| Plant symbionts                | Living plant roots                       | Rhizobia, other N <sub>2</sub> fixers, mycorrhizal fungi, other beneficial endophytes |
| Plant pathogens and herbivores | Living plant tissue                      | Pathogenic fungi and bacteria, rootfeeding nematodes, grubs, rodents, etc.            |

**Soil Quality** -Agricultural land use and the ongoing intensification of agriculture pose severe risks for soil degradation worldwide (see also: Principles and Practices of Soil Resource Conservation). Soil nutrients, microbial communities, soil erosion and physical properties are all affected by agricultural management, with potentially severe consequences for human societies (Setälä *et al.*, 2014). Soil organic matter/soil organic carbon are managed via the application of organic fertilizers (e.g. manure, slurry or compost), mulches or crop residues and crop rotations (e.g. including legumes with nitrogen (N) fixation) under organic agriculture replacing the application of mineral fertilizers in intensive, nonorganic agriculture. There is good evidence that organic agriculture leads to higher soil organic matter content and soil carbon stocks compared to nonorganic agriculture. These results partly reflect the fact that organically managed fields often receive external carbon input at higher rates and that diverse crop rotations are more common compared to nonorganic agriculture (Leifeld *et al.*, 2013; Leithold *et al.*, 2015). Organically managed soils can have significantly higher soil carbon content even if organic fields do not receive manure (Marriott and Wander, 2006), or if both organic and nonorganic fields receive manure over long periods (Birkhofer *et al.*, 2008). Positive effects of organic agriculture are also evident for N content and microbial parameters (biomass and activity) compared to nonorganic agriculture. Available phosphorous (P) and

potassium (K) contents, however, are less consistently affected by organic agriculture. Among the most important physical properties of agricultural soils are aggregate stability, water-holding capacity and bulk density. These properties contribute to the resistance of soils versus structural degradation and reduced nutrient leaching. Soil physical quality is often higher under organic agriculture for example, due to higher earthworm activity, a fact that contributes to the often lower soil erosion in comparison to nonorganic agriculture. Higher abundances of arable weeds and increased competition with crop plants may, however, also lead to the risk of high soil erosion in organic agriculture due to reduced crop plant densities. Soil quality is often argued as an ecosystem concept that integrates diverse soil functions, including nutrient supply, which leads to crop productivity (instead of seeing it as the continued ability of soil to supply nutrients to crops) Swift 2006. This understanding suite well to organic farming, since there are complex relationships between different system components and the system sustainability depends heavily on functioning of the whole system. It is then crucial to conceptualize the relationship of organic farming with soil quality for a sound appreciation of organic farming's impact on soil fertility. The integration of different components of organic practices enhancing soil properties to sustain soil health

**Ground and Surface Water-** Water leaches through agricultural soils and takes (primarily) nitrate ( $\text{NO}_3$ ) with it, causing N losses from arable fields and associated environmental problems (e.g. eutrophication). Levels of nitrate leaching in organic agriculture have been reported to be lower or equal to levels under nonorganic management per unit area, but higher per unit product. Higher nitrate leaching in nonorganic agriculture is usually related to larger N inputs, reduced use of cover crops or higher stocking densities. Major difficulties with studying effects of farming systems on leaching are the seasonal and interannual variation in rainfall and N mineralization processes. Nutrient budgets in organic agriculture rarely show surplus P, so that P leaching from organically managed arable land is of limited concern. The poor recycling of P and the strict regulation of potential P source constitute one of the main challenges in organic agriculture. The main sources of environmentally critical pesticides that contaminate water are synthetic herbicides, and organic agriculture does not contribute to these negative impacts on the environment. Pesticide leaching in organic agriculture would be limited to organic pesticides. These chemicals can have severe local consequences for non-target soil organisms (e.g. copper sulphate), but nothing is known about potential leaching of such substances (Shepherd *et al.*, 2003). Climate and Air the emission of greenhouse gases

(GHGs) from agriculture contributes to global warming. Nitrous oxide ( $\text{N}_2\text{O}$ ) is produced during nitrification and denitrification processes in soils that are fertilized with synthetic fertilizers. Organic agriculture contributes to  $\text{N}_2\text{O}$  emissions due to the production, storage and application of manure and due to the decomposition of green manure crops in the rotation. Studies observed higher  $\text{N}_2\text{O}$  emissions in organic dairy and crop farming in the Netherlands compared to nonorganic agriculture. In general,  $\text{N}_2\text{O}$  emissions are lower per unit area in organic agriculture, but higher per unit product. Studies on the emission of carbon dioxide ( $\text{CO}_2$ ) as another important GHG also show higher emissions in organic agriculture per unit product, but lower emissions per unit area compared to nonorganic agriculture. Methane ( $\text{CH}_4$ ) emissions in agriculture are the result of complex interactions between fodder type, livestock species and livestock numbers in animal breeding. Methane emissions per unit livestock decrease with increasing production intensity and this should result in higher methane emission per unit in organic livestock breeding. The major reviews about GHG emissions conclude that GHG emissions are lower in organic agriculture or not different from nonorganic agriculture if considered per unit area, but that organic agriculture may lead to higher emissions if considered per unit product (Mondelaers *et al.*, 2009; Skinner *et al.*, 2014; McGee, 2015)

### **Impact of Organic Farming on Soil Health-**

Organic soils tend to score higher when it comes to soil health metrics than conventional soils. For example, organic soils have greater biological activity, greater soil stability, more biomass and higher diversity than conventionally managed soils. Organically managed soils also tend to have higher water-holding capacity, porosity, and aggregate stability than conventionally managed soils, which can lead to yield advantages in extreme weather events such as droughts and flooding, meaning that organic may fare better as our planet continues to experience climate change.

- A. Cover crops** Cover crops are plants that are grown to benefit the soil rather than harvest income. They provide protection from soil erosion, nutrient losses, along with many other agroecosystem benefits. In organic systems, they can be used for weed suppression and are often a critical source of nutrients for cash crops through nitrogen fixation and green manure. There is an abundance of studies showing that cover crops enhance soil health overall, but there is sparse research comparing how cover crops affected soil health in organic systems. While this paucity of data clouded trends that may be apparent, it was clear that roll-killed cover crops

suppressed weeds better than disking. Additional research should focus on the impacts of cover crop species, termination methods, and amendment combinations on soil health outcomes. Research should also focus on the timing of nitrogen release from cover crops during decomposition. If nutrients are available too soon, they can lead to nitrogen leaching. If available too late, they can lead to nitrogen deficiency stress.

- B. Organic amendments** the use of synthetic nutrients is banned on organic farms, so organic farmers must rely on naturally-occurring fertilizers such as compost and manure for enhancing nutrient content in soils. The use of organic amendments has been shown to increase soil carbon sequestration, which may help to mitigate climate change by locking away carbon that could otherwise act as a greenhouse gas in the atmosphere. However, organic soil amendments can vary dramatically in nutrient content, carbon to nitrogen ratios, and timing of nutrient release, which has led to variability in the impacts of organic soil amendments on soil health. The variability in organic amendment type and treatment also makes it difficult to compare studies, but this project was able to uncover some general themes. Specifically, combining different organic amendments (such as vermicomposts in combination with manure) is better for soil health than using one type of organic fertilizer alone. Future research should focus on specific regional effects of fertilizer types and rates, and how timing of nutrient release can be synchronized with crop need.
- C. Rotation diversity and length Crop rotations**—the sequence of crops grown on the same land in succession— are a critical component of maintaining healthy soils. They break pest and weed cycles, help cycle nutrients, and reduce economic risks associated with single cropping strategies. Organic farms tend to have longer crop rotations than their conventional counterparts, which leads to higher on-farm diversity. This study found that most research on crop rotations focuses on the effect of rotation length, rotation complexity and grain versus forage rotations. Diversity in rotations was key to enhancing soil health, especially when it comes to including perennials, such as alfalfa, into the systems to improve soil health indicators including soil carbon, nitrogen and aggregate stability.
- D. Tillage** Tillage on organic farms is sometimes used as a form of weed control, but frequent tillage can destroy soil structure and lead

to soil organic carbon loss. However, there is growing interest in organic strategies that reduce tillage. Studies on organic systems show that reducing tillage can increase soil carbon, but the variable definition of “reduced tillage” makes it difficult to identify other potential trends. Unfortunately, organic no-till methods can decrease yields, so future research should focus on ways to reduce tillage without having a negative impact on yield. Alternately, shallow non-inversion tillage (also called “vertical tillage” or “strip-tillage”) can optimize both yields and soil carbon storage. Additional research comparing different methods of tillage (such as a gradient between chisel ploughing to shallow inversion tillage) would help optimize strategies that promote multiple parameters of soil health while not suppressing crop yields on organic farms.

- 1. Impact on physical properties of soil:** The physical properties of soil denote structure, texture, bulk density, porosity, water-holding capacity etc. (Hillel 1982) and positive effects of organic farming on soil physical properties viz. soil structure, water holding capacity, soil aeration and soil temperature are well-reported (Parthasarathy *et al.*, 2004. Pulleman *et al.*, 2003. Purohit, 2006. Reganold *et al.*, 1987). (Papadopoulos *et al.* 2014 reported to organic management can improve soil structure, organic matter content, and porosity in soil. Crop rotation is an important component under organic farming which directly and indirectly influences the physical structure of soil. Accumulation of organic matter in soil during the lean phase has a direct influence in the modification of soil structure (Clement and Williams 1987, Grace *et al.*1995). The architectural form of different root systems of several crops included in the crop rotation also helps to modify the soil structure (Chan and Heenan 1991). Mulching of soil surface with organic materials renders the soil soft, pulverized, and humid that ultimately creates a congenial environment for beneficial microbes to maintain bulk density and porosity in the soil (Lampkin 1990, Naeini and Cook2000, Pinamonti 1998). Organic farming adds more organic matter to the soil, which is the basic requirement for improving soil health Aguiar *et.al.*2013 and Basamba *et al.* 2006. Presence of this organic matter in soil increases its moisture retention capacity Altieri and Nicholls 2005. A combination of crop residue mulching and no-tillage increases soil fertility, crop production, and control soil erosion. Further, residue decomposition adds organic matter to the soil, which contributes to reduce the soil hydrological response, increase soil water repellency that reduces infiltration rates García-Moreno *et al.* 2013. Application of

organic fertilizer not only provides nutrient to the standing crop but also to the succeeding crop Jannoura *et al.* 2014. The improvement of soil physical properties due to organic farming has spatio-temporal dimension also. Lotter *et al.* 2003 reported that organic farming is better in areas having extreme rainfall because of the higher absorption and less run-off of water in the field.

**Soil Organisms with Tillage**

Most tillage kills some earthworms and other macro fauna, and fragments fungal mycelia. Tillage stimulates the growth of bacteria and their consumers (protozoa, nematodes), and speeds mineralization of SOM and nutrients. However, several tools can mitigate the impacts of necessary tillage on soil life. Microbial biomass and function in organic systems remains higher in chisel-plowed or shallow (3") tilled soils than moldboard-plowed or disked soils. The spading machine works deeply without inverting, pulverizing, or compacting the soil, and can improve vegetable yields over plow-disk. The blade plow undercuts cover crops, leaving residue on the surface and most of the soil profile undisturbed, conserving moisture and soil health in dry regions.

**Table 2:** Effects of farming practices on soil organisms and functions.

| Practice                        | Increases                                                                                     | Decreases                                                  |
|---------------------------------|-----------------------------------------------------------------------------------------------|------------------------------------------------------------|
|                                 | INPUTS                                                                                        |                                                            |
| Manure                          | Bacteria, protozoa, bacteria feeding nematodes; SOM (if moderate C:N)                         | Mycorrhizal fungi (if P builds up) SOM (if low C:N)        |
| Compost                         | SOM stabilization                                                                             | Mycorrhizal fungi (if P builds up)                         |
| Green crop residues             | Bacteria, SOM & N mineralization                                                              |                                                            |
| Dry crop residues               | Beneficial fungi                                                                              | Short term N mineralization                                |
| Concentrated NPK                | Breakdown of high-C: N residues and SOM, qCO2.                                                | N fixing & N-cycling microbes, mycorrhizal and other fungi |
|                                 | CROPPING SYSTEM                                                                               |                                                            |
| Diverse rotation without fallow | SOM, microbial diversity, nutrient cycling.                                                   |                                                            |
| Cover crops                     | Microbial biomass, active SOM, tilth (soil aggregation), mycorrhizal fungi (grasses, legumes) | N leaching                                                 |
| Sod phase                       | Active & stable SOM, biomass & diversity of most soil organisms,                              | N leaching, erosion, compaction                            |

|                                          |                                                                |                                                                  |
|------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------------|
|                                          | tilth, nutrient cycling                                        |                                                                  |
| Unplanted fallow                         | Soil erosion & compaction, nutrient losses                     | All soil life, especially plant symbionts, SOM, nutrient cycling |
| Livestock integration                    | Active and total SOM, nutrient cycling, most soil organisms    | Mycorrhizal fungi if P excesses accumulate                       |
| TILLAGE                                  |                                                                |                                                                  |
| Routine tillage (at least one pass/year) | Bacteria, protozoa, bacteria-feeding nematodes; mineralization | Most fungi, earthworms, other macrofauna, SOM stabilization      |
| Intensive tillage                        | qCO <sub>2</sub> , mineralization, soil erosion                | All soil life, SOM, tilth                                        |
| No-till, reduced till                    | Fungi, macrofauna, SOM stabilization                           | Mineralization of SOM & N, some bacteria                         |

- 2. Impact on chemical properties of soil:** Unlike conventional agriculture, organic agriculture follows the natural cycle to add essential nutrients for quality improvement. Organic farming has potential to maintain soil fertility and increase organic carbon in soil Pandey and Singh 2012. Application of different organic inputs like FYM, vermicompost, green manuring etc. ensures both the sustainability of soil organic carbon and supply of nutrients to the plants Thorne et.al. 2004. Application of good quality FYM improves the total nitrogen (Bhradwaj and Guar 1985) and organic matter in the soil, which is “an important substrate of cationic exchange and the warehouse of most of the available nitrogen, phosphorus, and sulphur; the main energy source for microorganisms; and is a key determinant of soil structure” (Ewel 1986). Significant differences and higher values of soil organic carbon, carbon stocks, and carbon sequestration rate were observed in organically managed plots compared to non-organic plots Gattinger *et al.* 2011. It is undoubtedly an important controlling factor for C:N ratio, total and available N, N mineralization, soil moisture, microbial activity, and soil texture (Agehara and Warncke 2005, Cabrera et.al. 2005, Eghball et.al. 2002). Strikingly, several studies have reported that organically amended soil holds more available N than the soil receiving inorganic fertilization (Chang and Cheng 2000, Khatik and Dikshit 2001, Rodriguez *et al.* 2005, Singh and Ghosh 1999, Sullivan *et al.* 2003) mainly due to relatively slower and constant mineralization rates, ultimately decreasing nitrogen leaching. Organic acids and humus fraction of decomposing matter are more efficient in releasing phosphorus and reducing its fixation in soil (Iyamuremye and Dick 1996). Nutrient supply through organic sources also ensures micronutrient availability to the plant (Parthasarathy *et al.* 2005).

3. **Impact of organic inputs on biological properties of soil:** Although many researchers confine the concept of soil quality to physical and chemical properties, others value biological parameter as an important aspect, which should be incorporated in soil quality assessment process (Van Bruggen and Semenov 2000). These biological properties are very important while assessing soil quality (Abawi and Widmer 2000, Doran and Parkin 1994, Pandey and Singh 2012) since soil quality is strongly influenced by the flora and fauna present in the soil. Soil micro-organisms are the living part of soil organic matter present in the soil (Dalal 1998, Friedel et.al. 2001, Smith and Paul 1990). The microbial biomass and microbial activities in soil are crucial to sustain the productivity of soil. For ensuring consistent release of nutrients to the plants, there is a need to have balanced ratio of microbial biomass and activity in soil Pandey and Singh 2012. Organic farming is reported to have enhanced both microbial biomass and microbial activity by 20-30% and 30-100%, respectively (Stolze et.al. 2000). The soil having high organic matter content ensures greater microbial activity and greater soil N supplying power than the soil having less organic matter (which is managed inorganically) Kramer *et al.* 2002. In addition to this, soil organic matter has a capacity to sink the atmospheric CO<sub>2</sub> and thereby increasing the carbon content in the soil, which further enhances the microbial biomass and respiration (Sparling *et al.* 2003). It has also been well documented that the organically managed soil enriched with several beneficial microorganisms like arbuscular mycorrhizal fungi for ensuring improved crop nutrition and decreasing soil borne diseases (Mader et.al. 2000). Arbuscular mycorrhizal fungi is a special fungal group, which makes symbiotic association with the plant's root system (Schussler et.al. 2001) enhancing plant nutrient uptake and water absorption. This mutualistic relationship primarily helps plant to take more P from the soil and also protects plants from several diseases. As organic farming increases the microbial activity, leads to increased competition, parasitism and predation in the rhizosphere, it collectively reduces the chances of plant disease infestation. Application of quality organic inputs enhances the microbial population in the soil (Chowdhury *et al.* 2000, Flareback and Mader 2000, Peacock et.al. 2001). Organic fertilizer application improved nodule dry weight, photosynthetic rates, N<sub>2</sub> fixation, and N accumulation as well as N concentration in several crops (Jannoura et.al. 2014). However, it was also found that organic agro ecosystem management strongly influences the soil nutrients and enzyme activity while it has lesser influence on

soil microbial communities (Bowles et.al.2014). Several composts like vermin-compost, farmyard manure etc. are generally used for nutrient management in organic farming, which ultimately promote the beneficial macro and micro flora in the soil (Singh 2003). Application of organic inputs like human urine, sewage sludge, municipal waste, deep litter, cattle slurry, cattle manure etc. ensures higher soil microbial biomass. Hence, household waste and sewage sludge help to maintain the highest number of colony forming heterotrophic bacteria in the soil (Mattana *et al.* 2014, Poulsen et.al.2013).

### **Soil biology monitoring and assessment**

An increase in microbial activity indicates that soil health is improving, provided the functions of mineralization and stabilization are in balance. Two indicators of this balance are microbial growth efficiency (MGE), the proportion of organic inputs that become new microbial biomass; and metabolic quotient ( $qCO_2$ ), respiration rate per unit microbial biomass. Farmers can use to monitor soil biological function, from the simplest to the more advanced include the following:

- i. Visual assessments of soil health: color, tilth (aggregation), surface porosity (rain infiltration), drainage, and resistance to root growth (test with wire field flag).
  - ii. Crop performance and resilience to diseases, drought, and other stresses.
  - iii. Total SOM (track trends in soil test reports).
  - iv. Crop nutrition from soil (how much fertilizer is needed to sustain yield).
  - v. Earthworm counts, other macro organisms, and visible fungal mycelia (especially in perennial crops with no or minimal soil disturbance).
  - vi. Lab tests for PMC and POX-C, or a soil health test such as the Cornell Comprehensive Assessment of Soil Health
  - vii. Participation in funded research projects to assess soil life through more sophisticated tests such as microbial biomass, enzyme assays, or microbial community analysis.
- 4. Organic Soils and Climate Change Mitigation**-Earth's terrestrial carbon is stored in soils and other than the ocean about 80%, it is the largest pool of carbon on earth. Humans manage the majority of the Earth's soils, and research shows that our management practices can

deplete the soil's carbon stores – releasing it back into the atmosphere – contributing to global climate change. Agriculture, in particular, has been linked to large losses of soil organic carbon worldwide. In fact, an article published in the Proceedings of the National Academy of Sciences shows that over the history of farming, human agricultural practices world-wide have resulted in a loss of 133 billion metric tons of carbon from the soil. It also points out the rate of carbon loss from agricultural soils has increased dramatically over the last 200 years as more land is converted to crop and rangeland. Fortunately, a number of studies show that with proper management, some agricultural practices can actually increase the carbon pool in our soils – making healthy soils part of the climate change solution. A study conducted by The Organic Center, in collaboration with Northeastern University, quantified the non-labile stable portion of carbon in over a thousand samples of organic and conventional soils in the United States, and found that organic soils had significantly higher levels of sequestered carbon than their conventional counterparts. These results build on past research showing higher levels of total carbon in organic soils, highlighting the potential of organic agriculture to increase the amount of carbon sequestration in the soil, contributing to climate change mitigation

5. **Organic farming and biodiversity:** Biodiversity in soil refers to a variety of taxonomic groups including bacteria, fungi, protozoa, nematodes, earthworms, and arthropods present in the soil (Van Bruggen *et al.* 2000). Intensification and expansion of modern agriculture have created a threat to biodiversity worldwide (Donald *et al.* 2001, Krebs 1999) and several studies have shown that it has been reducing the abundance and diversity of a host of plant and invertebrate taxa over the past four decades (Preston *et al.* 2002). On the contrary, organic farming helps to maintain biodiversity (Doles *et al.* 2001, Hole *et al.* 2005, Mader *et al.* 2002, Oehl *et al.* 2004). After a study of 20-years on agro-economic and agroecological performance of biodynamic, bioorganic, and conventional farming systems in Central Europe, organic farming resulted higher biodiversity and enhanced soil fertility than conventional farming (Mader *et al.* 2002). However, recent studies found no effect of landscape heterogeneity, and differences in any of the measured soil and microbial variables between conventional and organic farms; but N mineralization was higher in organic farms (Williams and Hedlund 2013)
6. **Soil management through Organic and Inorganic source of nutrients-** Organically managed soil had greater fragment size,

aggregate stability in water, and microbial biomass carbon than conventionally managed soil (Schjonning 2002). Moreover, at the end of 20 years of long-term crop rotation management in Switzerland, soil organic carbon and total N were greater under biodynamic than conventional management, but organic management and integrated management (combination of manures, inorganic fertilizers, and herbicides) were moderate (Flieabach *et al.* 2007). Soil microbial biomass carbon and dehydrogenase activity were greater under organic than that of conventional management, but basal soil respiration did not vary between systems. In North Dakota and Nebraska, under organic than that of conventional management. In Washington State, a comparative study of organic, conventional and integrated apple production systems from 1994 to 1999 indicated that the organic and integrated systems had higher soil quality and potentially lower negative environmental impact than the conventional system (Reganold *et al.* 2001). Limited studies of intensive organic farming systems in Australia have generally shown an increase in soil health compared to conventional practice. Nitrate leaching may be less under organic than conventional systems. It is reported that the bulk density of organic soil is less than the soil which was managed chemically, indicating better soil aggregations and soil physical conditions owing to increased soil organic matter. There is a 29.7% increase in organic carbon under organically managed farm (1.22%) as compared to conventionally managed farm (0.94%). Dehydrogenase, alkaline phosphate, and microbial biomass carbon were higher in organic soils by 52.3%, 28.4%, and 34.4%, respectively; as compared to conventional farms (Ramesh *et al.* 2010).

## **Conclusions**

To achieve sustainable crop and livestock production, the primary requirement is the maintenance of soil fertility and soil health. Organic farming systems being highly complex and integrated biological systems could be the potential technology option to maintain good soil health. Organic practice has both direct and indirect effect to soil properties as it affects more than one component of the system simultaneously. The previous studies on the impact of organic practices on different aspects of crop production, soil health and environment envisage the potentiality of the organic farming in maintaining the soil health and soil fertility.

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# Chapter - 6

## Organic Farming for Sustainable Agriculture in India

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### Abstract

In the post-independence era, India's most important challenge has been the production of adequate food for the growing population. Thus, the more productive species are used in irrigation, fertilizer, or pesticides. This combination of highly productive production technologies has helped the country to have more food as well as to contribute to soil health concerns, pollution, pesticide poisoning, and sustainable agricultural production. Therefore, scientists and policymakers are re-examining agricultural practices that rely heavily on organic matter instead of over-utilizing chemical fertilizers and pesticides. Organic farming can provide quality food without compromising on soil health and the environment; however, the concern is whether large-scale farming will produce enough food for most Indians. Certified organic products that include all kinds of food products including basmati rice, pulses, honey, tea, spices, coffee, oil seeds, fruits, grains, herbal medicines, and its value-added products are produced in India. Non-edible organic products include cotton, clothing, cosmetics, active food products, body care products, and similar products. The production of these crops and natural products is being reviewed in terms of sustainable agriculture in northern India.

**Keywords:** Organic Farming, Soil Properties, soil fertility, organic nutrients and organic crops

## **Introduction**

Organic farming has been practiced in India for thousands of years. The great Indian civilization was very prosperous in subsistence farming and was one of the most prosperous countries in the world, until the British rule. In traditional India, all farming was done using organic techniques, where fertilizers, pesticides, etc., were obtained from plant and animal products. The cow not only provided milk, but also bulls for farming and manure used as fertilizer.

During the 1950s and 1960s, India's growing population and a number of natural disasters led to severe food shortages in India. As a result, the government was forced to import grain. To increase food security, the government had to significantly increase food production in India. The Green Revolution (under the leadership of M. S. Swaminathan) became a major governmental initiative in the 1960's. To increase the grain production large area were brought under cultivation. Hybrid seeds were introduced. Organic and natural fertilizers were replaced with chemical fertilizers and localized pesticides were replaced with chemical pesticides. Large chemical factories such as the Rashtriya Chemical Fertilizer were established.

Key factors affecting consumers' demand for organic food are health awareness and public willingness to pay for a high-quality product. Generally, consumers of organic products are a wealthy, educated, and health-conscious group driven by strong consumer demand, open premium prices, and environmental concerns. Because of these hidden benefits, ordinary farmers are turning to organic farming. In Europe, government policies aim to revitalize the biodiversity sector through assistance, consumer education, and support through research, education, and marketing. India's agricultural systems go back more than 4000 years, and organic farming is widely available in the country. As stated in Artaxerxes, the farmers of the Vedic period had a good knowledge of soil fertility, seed selection, crop protection, planting seasons, and crop stability in different countries (Sofia et.al. 2006). Farmers in ancient India adhered to the laws of nature and this helped to maintain soil fertility for a relatively long time (Chandra and Chauhan 2004).

## **Sources of Nutrients**

Soil is a great source of nutrients for plant growth. The nutrients provided by the soil are called mineral nutrients. Non-mineral elements such as carbon (C), hydrogen (H) and oxygen (O) are released from the air and water during photosynthesis. Mineral soil nutrients are divided into two groups of macro and micronutrients. Macronutrients are further subdivided into two primary

and secondary nutrients. Basic nutrients are needed for plants in very large quantities. These are very popular; nitrogen (N), phosphorus (P) and potassium (K) are commonly called NPK. Medium nutrients are needed by plants in moderate amounts, these are calcium (Ca) magnesium (Mg) and sulphur (S).

Micronutrients are needed in relatively small quantities. They include iron (Fe), boron (B), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo), nickel (Ni) and chlorine (Cl). It is important to note that although soil nutrients are divided into different groups (based on quantity required by the plant), each nutrient element is equally important. Deficiency of any nutrient can reduce plant growth and yield. This is in accordance with Liebig's law of the minimum.

Currently, many optimistic estimates indicate that about 25-30 percent of India's agricultural nutritional needs can be met by a variety of biodiversity sources. The addition of whole N by FYM maintains crop production beyond the use of conventional N fertilizer. Since the estimates of NPK availability in organic sources are based on complete nutrient content, the efficiency of these resources to meet plant nutrient requirements is not guaranteed as mineral fertilizer. But the combined use of chemical fertilizers and various organic sources can maintain high crop yields, improve soil quality, and productivity in the long run (P.K. Chhonkar 2002). These natural sources in addition to providing N, P, and K also make untapped sources of basic nitrogen, bound phosphates, micronutrients, and decaying plant residues into an available species to make it easier for plants to absorb nutrients. The use of natural resources promotes the growth and function of mycorrhizae and other beneficial organisms in the soil and helps to reduce the incidence or deficiency of micro-nutrients and micronutrients and is able to maintain high plant productivity and soil health (Nambiar et al. 1992). Farmer, can earn a good income from organic crops and by incorporating high value crops like; sweet rice (*Oryza sativa* L.), table pea (*Pisum sativum* L.), and onions (*Allium cepa* L.) because of their critical needs in the domestic, national, and international markets (S. Kalyan, 2005)

### **Components of Organic Farming**

Important components of organic farming are biological nitrogen fixation, crop rotation, using crops residues, biopesticides, biogas slurry etc. Vermicomposting has emerged as a major component in organic farming which is very effective in enhancing soil fertility and growth of crops in a sustainable way. The various components of organic farming are: -

1. **Crop rotation:** For practicing sustainable agriculture there should be rotation of crops on the same land over a period of two years or more for maintaining soil fertility and control of insects, weed and diseases. For example, use of legumes in rotation improves soil fertility.
  2. **Crop Residue:** India has great potential of using residues of crops and straw of cereals and pulses in recycling of nutrients during organic farming. Crop residues when inoculated with fungal species improve physico-chemical properties of soil and crop yields.
  3. **Organic manure:** The organic manure is obtained from biological sources (plant, animal and human residues). Organic manure helps in increasing crop growth directly by improving the uptake of humic substances and indirectly promoting soil productivity by increasing availability of major and minor plant nutrients through soil microorganisms.
- a) **Bulky organic manure:** Bulky organic manure includes compost, FYM and green manure having less nutrients in comparison to concentrated organic manure. FYM: - Farm Yard Manure (FYM) refers to the well decomposed combination of dung, urine, farm litter and leftover materials (roughages or fodder).
- Compost:** - Large quantities of waste material (vegetable refuse, weeds, stubble, bhusa, and sugarcane trash, and Sewage sludge, animal waste, human and industrial refuse) can be converted into compost manure by anaerobic decomposition. Compost is used in the same way as FYM and is good for application to different type of soils and crops.
- Green Manuring:** - Green manuring is practice of adding organic matter to the soil by ploughing and adding into the soil undecomposed green plant tissues for improving physical structure and fertility of the soil. The green manure crop (legume crop) supplies organic matter and additional nitrogen. Commonly used green manure crops are; Sun hemp (*Crotalaria juncea*), Dhaincha (*Sesbania aculeata*), Cowpea, Cluster Bean, Senji (*Melilotus parviflor*, *Vigna sinensis*), Berseem (*Trifolium alexandrium*) etc. Rohit and Singh in 2020 studied the effect of green manuring (*sesbania*) on mustard. They observed that when sesbania was used as green manure the mustard average yield was increased by 29.48%.
- b) **Concentrated Organic Manure:** Oilcakes, blood meal, fishmeal, meat meal and horn and hoof meal (Concentrated organic manures) that are organic in nature made from raw materials of animal or plant origin and

contain higher percentage of vital plant nutrients such as nitrogen, phosphorous and potash, as compared to bulky organic manures.

### **Effect of Organic Nutrition on Crop Productivity**

Addition of organic matter in the soil is a well-known practice to increase crop yields. Sharma and Mitra in 1990 reported that the application of organic materials increased grain and straw yield of rice. Ranganathan and Selvaseelan in 1997 studied and concluded that the application of spent mushroom and rice straw compost increased rice grain yields by 20 per cent over NPK fertilizer as compared to FYM. Singh *et al.* reported that the application of 7.5 t FYM ha<sup>-1</sup> produced significantly more grain, and straw yields over unfertilized fields. All yield attributing characters of rice increased with increasing rates of FYM. Organic farming with dhaincha (*Sesbania aculeata* L.) made considerable improvement in grain yield of rice and Chickpea. Stockdale *et al.* 2001, narrated the benefits of organic farming to developed nations (environmental protection, biodiversity enhancement, and reduced energy use and CO<sub>2</sub> emissions) and to developing countries (sustainable resources use, increased crop yield without over reliance on costly inputs, and environmental and biodiversity protection). Singh, *et al.* 2015, concluded in a study that application of dhaincha and green gram as green manure, increases the availability of N, P, and K and improves the soil physico-chemical properties hence increase the rice productivity.

Many researchers reported that in an organically managed field activity of earth worm is higher than in inorganic agriculture. In the biodegradation process earthworms and microbes work together and produce vermicompost, which is the worm fecal matter with worm casts. Vermicompost provided macro-elements such as N, P, K, Ca, and Mg and micro-elements such as Fe, Mo, Zn, and Cu. The vermicompost contained 0.74, 0.97, and 0.45 per cent nitrogen, phosphorus, and potassium, respectively.

In low-income agriculture, crop production under organic farming is comparable to that under conventional farming. Tamaki *et al.* in 2002 studied and concluded that the growth of rice is good under continuous organic farming rather than conventional farming. Agroeconomic study of practices of growing maize with compost and liquid manure top dressing in low-potential areas showed significantly better performance than those of current conventional farmer practices of a combined application of manure and mineral fertilizers. Maize grain yield was 11–17 per cent higher than those obtained with conventional practices.

Productivity of the crop during the initial year in an organically managed

field is lower than in subsequent years as soil fertility levels increase over time as organic materials are added in the organic management system. Similar conclusion was made by Surekha in 2007, that there is a gradual increase in grain yield with the use of organic fertilizers over a period of time. Chan *et al.* 2008, showed that the input of organic rice production in three different regions was 46, 25, and 22 per cent higher than conventional rice production, but rice yield was only 55, 94, and 82 per cent of conventional rice production, respectively. However, the cost of lower yield with higher inputs is compensated by the higher premium prices of organically crops in the markets.

Vegetables are highly responsive to organic sources of nutrients and profitable to farmers. Kalembasa, 1997 reported that vermicompost application of 15 kg per square meter gave the highest yield in tomato crop. Singh *et al.* 1997 studied the response of chilli (*Capsicum annuum* L.) to vermicompost and observed that the application of vermicompost increased the microbial activities and had a positive effect on the performance of crops having higher number of branches and fruits. Tomar *et al.* 1998 recorded the highest yield (97 g plant<sup>-1</sup>) through vermicompost in brinjal (*Solanum melongena* L.). They also reported that the application of vermicompost significantly increased leaf area in carrot (*Daucus carota* L.) plants. Kalembasa and Deska in 1998, obtained significantly higher yield of sweet pepper (*Capsicum annum* L. var. *grossum*) with vermicompost. Reddy *et al.* in 1998 recorded maximum plant height at harvest and days to first flowering, and branches with the application of vermicompost (10 t ha<sup>-1</sup>).

### **Effect of Organic Nutrition on Quality Parameters of Crops**

Decrease in organic matter content of soils due to cultivation and erosion have been a major concern related to sustainability of agriculture. Therefore, management practices that increase the organic matter content were deemed desirable to soil quality and productivity. Moreover, soil organic matter increases following repeated applications of solid cattle manure. Yadav and Vijaya kumari (2004) carried out an experiment to assess the effect of vermicomposted vegetable waste on the biochemical characters of chilli and found that the protein was higher at 60 (113 mg g<sup>-1</sup>) and 90 DAS (79 mg g<sup>-1</sup>). The carbohydrate content was higher in vermicomposted treatment at 60 DAS (15.34 mg g<sup>-1</sup>). Chlorophyll (2.61 mg g<sup>-1</sup>) and total chlorophyll (3.62 mg g<sup>-1</sup>) contents were observed at 60 DAS, while chlorophyll a (1.01 mg g<sup>-1</sup>) was higher at 90 DAS as compared to inorganic fertilizers. In another experiment, Haase *et al.* in 2007 suggested that tubers from organic potato cropping may be expected to have sufficiently high tuber dry matter

concentrations (19 per cent) for processing into French fries without impairing the texture of the fries when concentrations exceed 23 per cent. Similarly, Dixit and Gupta in 2000 studied and observed that application of FYM at 10 t ha<sup>-1</sup> alone increased the economic yield and quality parameters like hulling percentage, milling percentage, and protein and amylose content of rice cv. Saket

Mourao *et al.* (2008) found that organically grown potato cv. Virgo yielded 66 per cent of the conventional crop, whereas Raja yielded 47 per cent. The nitrogen uptake of organic crop (tubers and foliage) was 37.0 kg/ha for Raja and 50.5 kg/ha for Virgo, respectively, 21 and 28 per cent of nitrogen uptake by same cultivars grown with mineral fertilizer. Although foliage nitrogen content was increased for the conventional crops, difference between N content of organic and conventional tubers were not significant, as well as for K, Ca, and Mg. Maheswari *et al.* (2004) studied the effect of foliar organic fertilizers on the quality and economics of chilli and concluded that the vermiwash treated crop has highest ascorbic acid content (175.23 mg/100 g).

### **Effect of Organic Nutrition on Soil Fertility**

Minhas and Sood (1994) also reported that the organic matter after decomposition release macro- and micronutrients to the soil solution, which becomes available to the plants, resulting in higher uptake. Organic farming was capable of sustaining higher crop productivity and improving soil quality and productivity by manipulating the soil properties on long term basis. It was reported that organic and low-input farming practices after 4 years led to an increase in the organic carbon, soluble phosphorus, exchangeable potassium, and pH and also the reserve pool of stored nutrients and maintained relatively stable EC level (Clark *et al.* 1998; Gaur *et al.* 2002). Normal composting takes a long time leading to considerable loss of organic materials as CO<sub>2</sub> or does not contribute to the organic pool. Bulluck *et al.* (2002) reported that the use of compost raised soil pH from 6.0 to 6.5 and reduced the broadleaf weed population by 29 per cent and grassy weed population by 78 per cent. Narayana and Patiram (2006) concluded that the decline in soil reaction might be due to organic compounds added to the soil in the form of green as well as root biomass which produced more humus and organic acids on decomposition. Urkurkar *et al.* (2010) reported that there is 100 per cent supply of nitrogen, i.e., 120 kg/ha for rice and 150 kg/ha for potato in a rice-potato cropping system. He also concluded that 1/3 each from cow dung manure, neem cake, and composed crop residue appreciably increased the organic carbon (6.3 g kg<sup>-1</sup>) over initial value (5.8 g kg<sup>-1</sup>) as compared to supply from inorganic fertilizers alone. However, availability of phosphorus

and potassium did not show any perceptible change after completion of five cropping cycles under organic as well as integrated nutrient approaches.

### **Effect of Organic Nutrition on Soil Biological Properties**

Compost contains bacteria, actinomycetes, and fungi, hence a fresh supply of humic material not only added microorganisms but also stimulated them (Balasubramanian, et al., 1972). Gaur *et al.* 1973 reported that compost played an important role in control of plant nematodes and in mitigating the effect of pesticides through sorption. Sorption is the most important interaction between soil/organic matter and pesticides and limits degradation as well as transport in soil. Pesticides bound to soil organic matter or clay particles are less mobile, bioavailable but also less accessible to microbial degradation and thus more persistent. Composting material added plenty of carbon and thus increased heterotrophic bacteria and fungi in soil and further increased the activity of soil enzymes responsible for the conversion of unavailable to available form of nutrients. The application of FYM with *Rhizobium* and inoculation of PSB with *Rhizobium* augmented soybean (*Glycine max* L. Merr.) production.

Agricultural practices have had an impact on soil bio- physiochemical properties. Densities of bacteria, protozoa, nematodes, and arthropods in soils under organic farming were higher than under conventional farming. Bulluck *et al.* in 2002 reported that organic amendments enhanced beneficial soil microorganisms, reduced pathogen population, total carbon, and cation exchange capacity, and lowered down bulk densities, thus improved soil quality.

The National Academy of Agricultural Sciences (NAAS) recommended a holistic approach involving integrated nutrient management (INM) and integrated pest management (IPM) for enhanced input use efficiency and adoption of region-specific promising cropping systems as an alternative organic farming strategy for India and to begin with the practice of organic farming for valued crops like spices, medicinal plants, fruits, and vegetables.

### **Market for Organically Grown Food**

Consumers worry about high levels of saturated fats, sugarcane, salt in the diet and the risks of ingredients and pesticide residues, resulting in the need for healthy foods especially organic foods. In addition, awareness of the environmental damage associated with the use of modern agricultural techniques, especially agricultural chemicals, is increasing. At the same time, food surplus, especially in Europe, has led to the promotion of organic farming where yields are low which leads to reduced availability. Although the above

factors have contributed to the growth of the organic food market, it is interesting to note that there have been no major promotions in organic food. However, the media has become increasingly sensitive to organic farming, which has largely compensated for the lack of product promotion through marketing channels. In this context, marketing ideas need to be highlighted but cannot be completely ruled out. Therefore, paying close attention to marketing is an important part of successful organic farming. As the demand for organic products increases over the years as people become more aware of the level of food insecurity and awareness of the effects of nature due to overuse of chemicals in agriculture. They also suggest that if organic products have a well-defined marketing channel and ensure high prices the chances of expanding the area under organic farming become wider. When asking for ways to improve organic farming the following steps can be encouraged:

- Improve marketing channels
- Ensure the premium price of organic products
- Ensuring regular access to organic compost
- Establish organizations that will promote organic farming

### **Problems in Marketing Indian Organic Products**

- Expected prices are very high in terms of quality
- Low quality consistency
- Slow shipping, import restrictions on Indian organic products
- Time-consuming and difficult paperwork while working with export authorities
- Poor customer service from Indian traders after sales is a major problem in foreign advertising
- Lack of proper marketing network marketing implementation
- Less effort to develop domestic markets

### **Conclusion**

Organic farming is a farming system that promotes healthy natural, social and economic products for food and fiber. As awareness of the harmful effects of chemicals on health, soil, environment, etc., grows; which is why inorganic farming is changing your approach to organic farming. India with a wide range of agro climates has great potential for organic farming and most of the products are produced naturally in India. The high price of organic products and the lack of proper marketing activities in the domestic markets are major obstacles to organic farming in India.

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# Chapter - 7

## Bio-dynamics in Organic Agriculture

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### Abstract

The term & quot; bio-dynamic farming & quot; refers to using the energies that produce and sustain life. Through human efforts, the planet can be healed using vital energies through the bio-dynamics process. Regularly applying biodynamic preparations allows cosmic activity to enter the soil and affect the plants through the soil. Energy from the sun, the ground, and the cow is used in biodynamic farming. There are many similarities between organic farming and bio-dynamic farming. Both emphasize the significance of good soil health, forbid the use of synthetic pesticides, and promote the use of compost, green manure, and integrated pest and weed management. The goal of the biodynamic concept in organic agriculture is to create a system that brings balance to all elements that support life.

**Keywords:** Bio-dynamic farming, Organic Agriculture, Sustainable agriculture

### Introduction

A comprehensive, ecological, and moral approach to farming, gardening, food, and nutrition is known as biodynamics. Dr. Rudolf Steiner, a scientist and philosopher, is the founder of biodynamics. His 1924 lectures to farmers pioneered a new approach to fusing scientific knowledge with an appreciation of spirit in nature. Since the 1920s, biodynamics has advanced and changed as a result of the cooperation of numerous farmers and scientists (Steiner, 1992). Thousands of flourishing gardens, farms,

vineyards, ranches, and orchards all around the world are practicing biodynamics. Anywhere food is cultivated, biodynamic principles and methods can be used with careful consideration for scale, landscape, climate, and culture. Anthroposophy, also known as the wisdom (knowledge) of the human being, was created as a result of this impact and his own research:

**Anthropos=human being Sophia=wisdom**

Recognizing that the human being (Manushya) is a spiritual entity is at the core of anthroposophy (Purusha). Steiner responded to the farmers' need for assistance during the early days of chemical farming in Europe when they saw the soil quality, produce quality, and seed viability rapidly deteriorating. A general decline in vitality had been apparent to them. Steiner then offered an alternative perspective on farming and the planet as a whole, demonstrating the links and interdependence of all living things.

**Bios=life dynamic=energy**

He demonstrated how contemporary science, and hence chemical agriculture, was founded on the observation of living nature and the intricate linkages that were continually changing within it, as opposed to the study of dead things in laboratories. He mentioned how, in the past, farmers had an innate understanding of how the motion of the planets and stars affected the lives of plants, animals, and people. He also included the universe with its moving planets and stars in this web of life. To understand how to coexist with nature most effectively as modern humans, we must rediscover this relationship, but this time in a very aware, quantifiable way.

Biodynamics is especially interested in the higher forces, the finer energies, and how they affect plants, animals, and people. Life is a study of energy from the course to the fine. The soil, and by extension, everything that grows there and every living thing that consumes those plants, is balanced and healed as a result of this awareness and interaction with the life energies.

## **1. History**

The foundation of human life is agriculture. Simply but, we need to cultivate food in order to eat every day and to maintain our bodies, brains, souls, and spirits! One can see that throughout human history, our songs, artwork, crafts, and tools have all evolved from our work on the earth. But we have lost touch with our source of life over the past 100 years, and the pace has accelerated during the last few decades. Chemical farming is a byproduct of the World Wars, when it was discovered that the leftover

chemicals from weaponry and fighting could be utilized as fertilizers and pesticides. Fossil fuel from the Earth, which is unsustainable and will eventually run out, is the source of agricultural chemicals.

Hybrid seeds, which are unable to create their own seeds once grown and instead depend on hybrid seed businesses, were also developed during the Green Revolution in the 1960s and 1970s. Additionally, the plants grown from these hybrid seeds are substantially weaker and require larger dosages of fertilizer and insecticides. The most current threat to the equilibrium and wellbeing of not only the Earth but also of us as humans is the recent introduction of genetically modified (GM) seeds (which go hand in hand with specialized herbicides, insecticides, and fertilizers). Due to the significant economic benefits associated with GM seeds, developing nations are unavoidably under pressure to adopt and legalize the usage of these seeds.

Today, we are acutely aware of the negative impacts of chemical farming on our health, farmers' livelihoods, soil health, and the welfare of all living things. In many areas, the soil is becoming harder and less able to replenish itself, requiring increasing amounts of chemical fertilizers to grow crops and piling up enormous debts for the farmers. Unknown diseases and disorders affecting both humans and animals are also emerging, along with new pests and diseases those are resistant to chemical pesticides. Many people are becoming aware that we are in the midst of a worldwide catastrophe. The biodynamic farming approach took a much delayed start but has gained popularity across the globe in recent decades. Farmer and gardener associations that practice biodynamic farming as well as certification organizations that guarantee the produce supplied by granting a Demeter certificate exist.

### **DEMETER=Greek goddess of the Earth**

Using biodynamic techniques, a living soil is created that is in harmony with the planetary and cosmic rhythms. The intelligence and consciousness of the person caring for this area of the planet—the "ordering principle"—lie at the core of this endeavor. This profound understanding is founded on observation, a relationship with the land, Nature and love.

## **2. Main effects of using biodynamic agriculture**

- To boost the nutritional value of food
- To replenish natural resources like the soil (by reintroducing organic matter), the seeds, and the water

- To establish a personal connection with the environment we live in, with Nature, which we are a part of, and to learn how to cooperate
- By supporting nature when it is weak due to continual use, most importantly, to serve the Earth and its inhabitants

### **3. Principles**

The following categories are taken into account in order to create a system that balances all elements necessary for life:

#### **Substance and Energy**

Chemicals alone cannot sustain life; it requires the interaction of matter and energy. For instance, for plants to flourish, they require earth and water as well as sunshine and warmth. A balanced system is created by the interaction of matter and energy. We need to eat food that will supply the energy because we require both substance and energy to survive. Only plants that have developed in a balanced soil can provide us with both substance and energy (via trace minerals, enzymes, and growth hormones).

#### **Soil**

One must focus primarily on the composition and vitality of the soil, including its nutrients, trace elements, microbes, worms, and other animals, in order to grow healthy, vital plants. The soil is basically a living network of connections and relationships. The plants that grow there will be stronger, healthier, and of higher quality if the soil is balanced in its life forces. No chemicals are needed. To be productive, the soil's structure must be crumbly, friable, properly aerated, and deep.

#### **Organic matter**

Effective usage of organic matter is necessary to develop this healthy, living soil. Building compost piles and utilizing biodynamic compost preparations are two ways to accomplish this.

#### **Humus**

This enigmatic, mystical element provides energy for life and transports all the nutrients plants require to flourish. It retains water and holds the soil's fertility in a steady manner. Rich, black, moist, and smelling fresh, humus is entirely digested raw organic matter. When converting to biodynamic farming, promoting the creation of the soil should be the top priority because this is the foundation for building it up.

## **Cow Manure**

This is a very special substance that the holy animal Cow gave to us and is necessary for a healthy soil ecosystem. The lengthy digesting process of the cow adds a lot of good bacteria to the faces, making cow dung unique. It is utilized as a starter for compost heaps, for its nitrogen concentration, and in the creation of biodynamic preparations.

## **Cosmic Forces**

Utilizing the preparations and adhering to the sowing calendar to recognize and work with the effects of celestial bodies on plant growth.

## **4. Features Of Biodynamic Farming**

### **A Biodynamic Farm is a Living Organism**

Every biodynamic farm or garden is a complete, integrated organism. Fields, forests, plants, animals, soils, compost, people, and the spirit of the area are just a few of the interrelated components that make up this organism. In order to enhance the wellbeing and vitality of the whole, biodynamic farmers and gardeners strive to nourish and harmonies these elements. In order to establish and evolve their farm as a distinctive individuality, biodynamic practitioners also make an effort to listen to the soil and perceive any potential emerging needs.

### **Biodynamics Promotes Biodiversity**

The diversity of natural ecosystems and the distinctiveness of each terrain serve as inspiration for biodynamic farms and gardens. Plant diversity can be increased by using a variety of crops, including annual and perennial vegetables, herbs, flowers, berries, fruits, nuts, cereals, pasture, fodder, native plants, and pollinator hedgerows. The diversity of domestic animals is also advantageous since each species has a particular relationship to the land and produces manure with a distinct composition. It is possible to gradually increase the variety of plant and animal life by beginning with a modest number of primary crops and one or two animal species (even tiny ones like earthworms or honeybees), and then adding more as the farm organism develops.

### **Plants and Animals Come Together in Biodynamics**

Animals and plants coexist in natural ecosystems to fulfil complementary functions in the web of life. Many conventional and organic farms solely produce cattle or only grow crops, which, while in some ways more efficient, can lead to unbalances such nutritional deficiencies in plants or pollution from excess manure (if only raising animals). Plants, animals,

and soil are brought together in biodynamic farms and gardens through deliberate, living connections so that they all contribute to and balance the total.

### **Biodynamics Generates on-Farm Fertility**

With the use of chemical fertilizer or hydroponic growing, biodynamic plants are grown in the ground in living soil, which offers a level of nutrition and health that is unattainable. By using cover crops, composting, integrating animals, and crop rotation, biodynamic farms hope to create their own fertility. Composting creates a harmonious relationship between soil, plant matter, and animal manures, transforming them into a rich source of strength and fertility for the farm organism. Including a variety of animals improves the soil's fertility by aiding in the cycling of nutrients. In addition to increasing plant diversity and providing the soil with oxygen and nitrogen, cover crops help improve soil fertility on farms. Crop rotation promotes variation in the soil's creative expression while balancing each crop's needs. Together, these techniques help the farm progress toward equilibrium and resilience by reducing or eliminating the requirement for imported fertilizers.

### **Compost is enlivened with Biodynamic Preparations**

Six preparations prepared from yarrow, chamomile, stinging nettle, oak bark, dandelion, and valerian are used to enrich and animate biodynamic compost. Each of these healing plants goes through a distinct transformation process that connects it to the land, the seasons, and the animal life. Combining these compounds enhances their therapeutic effects, promotes the development of helpful bacteria and fungi, and produces highly concentrated ingredients that direct the compost's development. Just after the compost pile is constructed and again after it has been turned, a small amount of each preparation is added. By stabilizing nitrogen and other nutrients, increasing microbial diversity, and increasing the composting process' sensitivity, biodynamic preparations improve the quality of the compost. Compost made using biodynamic principles increases soil life and stable organic matter while adjusting the soil to the overall farm organism and external stimuli (Carpenter, *et. al.*, 2000). Additionally, biodynamic compost increases the amount of carbon in the living world, aiding in the rebalancing of the climate.

### **Biodynamic Sprays Enhance Soil and Plant Health**

Several biodynamic preparations are used as poetized liquid sprays in addition to the compost preparations to provide healing, vigor, and sensitivity to the farm and garden. Horn manure, which is created by burying

cow manure within a cow horn over the winter, improves the life of the soil and the interaction between soil and plants (Spaccini, *et al.* 2012) Horn silica is made from pulverized quartz crystals that are buried in a cow horn over the summer. It accelerates photosynthesis, increases ripening, and increases plant immunity. Horsetail tea balances the watery element in plants and soil and aids in the prevention of fungus illnesses. In order to help plants grow in a healthy and balanced manner, access the full spectrum of nutrients they require, and become more resistant to pests, diseases, and extreme climate conditions, biodynamic spray and compost preparations work together to bring plants into a dynamic relationship with soil, water, air, warmth, and cosmos (Fritz, 2014) .

### **Biodynamic Farmers Cultivate Awareness**

The practice of biodynamic agriculture encourages us to engage in mindful and original dialogue with nature. We grow close relationships with our particular farm creatures and increase our capacity for perception, introspection, and imagination by paying attention to, feeling, and listening to the land. A set recipe or prescription is not what biodynamics is. Developing awareness makes it easier for us to express the full vibrancy of the farm organism and work creatively with the dynamics of the land and larger bioregion.

### **Biodynamics Supports Integrity and Diversity in Seeds and Breeds**

Heirloom, open-pollinated, non-GMO seeds and heritage breeds of animals are preferred by biodynamic farmers and gardeners. In order to create distinctive, locally-adapted, and sensitive plants and animals with excellent nutrition and flavor as well as resistance to pests and diseases, biodynamic farms strive to produce seed and animal stocks from within the farm. When this is not possible, selection and breeding are incorporated into farm activities. In developing plants and animals that may live in the present and contribute to the health of the farm and community, earthly and cosmic factors are taken into account, just as they are in other parts of biodynamics.

### **Earth and the Cosmos Move in Time with Biodynamics**

The rhythms and cycles of the earth, sun, moon, stars, and planets are observed by biodynamic farmers and gardeners, who also try to comprehend the subtle ways that the environment and larger cosmos affect the growth and development of plants and animals. Detailed astronomical data and recommendations for the best times to sow, transplant, cultivate, harvest, and use biodynamic preparations are provided by biodynamic calendars, which aid in this awareness and understanding.

## **Biodynamics Treats Animals with Respect**

Domesticated animals are cared for by biodynamic farmers in ways that promote their innate wellness and the full expression of their nature. Animals are never fed animal byproducts; instead, they are always provided food that is suitable for their digestive systems. Kids, lambs, and calves are raised on herd milk rather than milk substitute. Both cows and chickens maintain their horns because each portion of the animal serves a crucial natural purpose. All animals have access to the outside, free range foraging, as well as lots of room to roam.

## **Biodynamics Approaches Pests and Diseases Holistically**

The main goals of biodynamics are to provide balanced nutrition, promote strong immunity, and foster the best possible circumstances for soil, plant, and animal health. Pests and diseases have few places to grow when farms and gardens use a wide variety of plants and animals and provide habitat for natural predators. It might be argued that when a disease or pest manifests itself, it frequently indicates an imbalance in the farm organism and is nature's attempt to repair the imbalance. Biological controls can be applied in the event of an outbreak, but a biodynamic farmer also seeks to identify the underlying imbalance and determines how to modify management procedures to restore the farm organism to higher health.

## **Biodynamic Certification Upholds Agricultural Integrity**

Demeter International oversees the Demeter Biodynamic® Standard for certification, which was created in 1928. There are more than 5,000 accredited farms worldwide, covering more than 400,000 acres. Demeter USA ([www.demeter-usa.org](http://www.demeter-usa.org)) oversees biodynamic certification in the United States, which builds on the USDA organic standard while imposing additional standards. Beyond organic certification, the Demeter Biodynamic Farm Standard mandates that the entire farm, not just one crop, must be certified; that crops and livestock be integrated; that animals be treated humanely; that imported fertility be kept to a minimum; that biodynamic preparations be applied regularly; that at least 50% of the feed for livestock be grown on-site; and that at least 10% of the farm's total acreage be set aside for biodiversity and the farm upholds standards of social responsibility.

## **The Benefits of Biodynamics for Social and Economic Well-being**

Biodynamic farmers are motivated by the true needs of people and the planet, and these demands frequently go beyond just growing food. The vast majority of biodynamic initiatives are inspired by Steiner's observations on social, economic, and spiritual life as well as agriculture and strive to

demonstrate the triple bottom line principles (ecological, social, and economic sustainability). Biodynamic farmers created community supported agriculture (CSA), and many biodynamic practitioners work with other farms as well as with clinics, spas, social therapy homes, dining establishments, and other enterprises. Biodynamics is both a cutting-edge concept in regenerative agriculture and a potent movement for new theories and practises in all areas of life connected to food and the land.

### **Future Regenerative Solutions are provided by Biodynamics**

Biodynamic farming and living promotes healing for the land, plants, animals, people, and planet. It is a mindful, inclusive, and responsible method of living and farming. Each individual, self-sufficient farm organism generously supports the ecological, economic, social, and spiritual health of its local area as well as the health of the entire living Earth. We can access new capacities in human creativity through biodynamics in order to detect and respond to the demands of the Earth and to unveil novel solutions in a live and dynamic way.

#### **5. Converting a farm to biodynamics**

- The important criterion is to sustain the fertility of a farm that lasts for future. The rules that must be adhered to are
- All water soluble fertiliser short-term manuring for rapid growth is stopped. This results in plants that are nutritionally imbalanced and destroys the soil's structure.
- Put an end to any chemical weed-control techniques that could leave behind harmful residues that would prevent the growth of active soil life.
- The type of livestock kept on the farm is crucial because it has a special impact on the fertility of the soil.
- Promote the growth of earthworms, other soil microorganisms, and legumes. The biodynamic preparations make this better. This increases the soil's microbial life and balances the availability of nutrients. They also have an impact on humus's ongoing development.
- Ample trees are required to offer cover and shade, preserve moisture, guard from wind, and serve as predators.

#### **Biodynamic Preparations**

The effects of the planets, silica, and lime on the soil and plants are

enhanced by using these straightforward, all-natural homoeopathic remedies. They are also used to speed up the decomposition process and potential life energies in compost piles. In addition to six preparations for composting, Dr. Steiner provided two preparations that could be sprayed directly on the plants or soil.

## **Crop Rotation**

Crop rotation, proper soil cultivation, and other organic farming methods: intelligent planning to let the soil rest after heavy-feeding crops (such as potatoes, tomatoes, cabbage), by sowing green manures (legumes, clover) and covering the soil (grass, clover) so that it can build up its humus content and nitrogen levels; also mulching to improve soil structure, water and temperature balance, and weed control; companion planting to enhance growth and to control weeds; companion planting to enhance growth and to control pests; using herbal tea sprays, special tree paste for fruit trees, creating raised beds, disturbing the soil as little as possible by shallow digging/ploughing and avoiding stepping on it or working it when wet, especially clay soils.

## **Peppering**

Collecting insects, weed seeds, or dead animal skins and burning them at the right time according to planetary positions can help solve an unbalanced insect, animal pest, or weed problem. The ash can then be made into a homoeopathic remedy and sprayed on the land. This works well as a biodynamic substitute for chemical sprays.

## **The farm organism**

The healthier a farm is, the more self-sufficient it may be. The goal is to have a diverse range of plants and animals, and to bring in something from outside (such as manure or bio-pesticides) only if there is an imbalance that needs to be corrected, such as medicine. The fanner, the human being who observes and has a strong interaction with everything on the farm and makes decisions, is at the heart of the farm organism. Water source and balance are important components of the farm, as are the prevention of soil erosion by planting trees and hedges, which also help with wind protection and provide animal habitat, and being conscious of insect life and balance, which may include looking after honey bees. As a result, the farmer is accountable for many creatures and for establishing proper relationships, and he is the temporary steward of the land rather than the owner.

## **Weeds, Pests and Diseases**

Weeds developing in specific locations indicate a soil shortage, just as

pests and illnesses indicate a flaw in agricultural operations. They are indicators that assist us understand where the problem is and aid in the correction of imbalances. They are not enemies, but rather buddies! It is well understood and confirmed that insect pests and illnesses only attack weak plants, therefore balancing the situation and motivating us to be better farmers and gardeners.

## **6. Practical Application**

- Walk around your land every day and become familiar with all of its aspects: minerals, rocks present, type of soil, wild plants growing, types of weeds, insect life, animals present day or night, electric wires crossing over the land, underground streams, presence of water, weather patterns, people living on or using the land.
- Implement environmental controls: plant hedges and trees for wind protection, maintain proper drainage, and be mindful of water quality, use, and collection.
- Introduce soil-protecting crop rotations and cover crops.
- Improve soil cultivation practices.
- Introduce green manuring, carefully plowed or dug under.
- Mulch as much as possible; the Earth wants to be covered and will cover itself with weeds!
- Create compost heaps and treat them with the preparations: do not throw away any organic leftovers and gather everything. Compost manure and all other organic materials first, and then apply when entirely broken down! Any under-com posted pieces can be sieved and re-decomposed. Larger branches than your wrist should be composted separately because they will take much longer to decompose.
- As needed, supplement with Cowpat Pit Preparation, Panchagavya, or natural liquid fertilisers (equisetum tea, fermented nettle manure).

## **7. Organic Vs Biodynamic**

For one thing, biodynamic farming incorporates a few extra substances, such as fermented manure and plant and mineral-based preparations, into the soil, crops, and compost, in addition to all of the approaches utilised in organic farming. These compounds are supposed to stimulate the soil nutrient cycle, the creation of compost, and photosynthesis.

Steiner presented another distinct and crucial aspect of biodynamic farming: the flow of cosmic energy in all aspects of farming. Biodynamic farming is also a well-thought-out and tested strategy that may be applied to farm structures in general. Its primary ideology emphasises the development of a farm that functions holistically as one unit, with its soil, animals, humans, and plants envisioned as diverse "organs of one living organism." The health of the "farm as an organism" is dependent on each of its organs cooperating with the other organs and with the environment. Energies must flow between each organ in tandem with cosmic energy, resulting in the construction of a self-sustaining farm.

To take a step back and look at it more practically, a farm's manure and compost needs can be met by using farm waste, legumes, cover crops, and animal waste. An integral component of biodynamic farming is well-managed livestock. Weed and pest control is accomplished through mechanical or physical removal, homoeopathy, crop rotation, and other non-chemical methods.

Biodynamic agriculture is a subcategory of organic agriculture in general. It employs several biodynamic soil and plant preparations based on various compost, minerals, plants, and herbs, with all farm activities regulated by the lunar calendar.

## **8. Positive Impact**

Biodynamic preparations influence the soil microbial community both directly and indirectly by altering the environment and boosting microbial development. A change/increase in the microbial community regulates plant diseases and promotes nutrient availability in the soil. Artificial microbe additions are typically short-lived in the absence of a suitable supportive environment. The number and composition of the microbial community are determined by the availability of food and habitat for helpful microbes. Repeated application in conjunction with habitat modification approaches results in long-term changes in the soil microbial community.

Since this agronomic system is based on a holistic approach to the entire farm, the use of preparations alone will not be defined as a biodynamic farming approach. However, the only method to compare the outcomes of different farming systems is to investigate the impact of various preparations on the plant and the soil. Thousands of farms are using biodynamic methods and preparations, indicating that there are substantial benefits.

## **9. Advantages**

- Production of high-quality fruits and vegetables with strong flavors

and high nutrient levels (protein and vitamin content)

- Yields that are always above average, higher on average than those produced by organic farming, and consistently high over time, as opposed to chemical farming's falling yields as the soil mineralizes and pest populations become unbalanced and a problem.
- Few problems with livestock and plant diseases
- There is no spread of insect pests and no significant economic damage as a result of their presence: The issue of insect pests is one of balance and control, which can be restored through proper management such as planting shrubs and trees to house natural predators.

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