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Eco-friendly Products and Practices-A Key to Successful Organic Farming

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Abstract

Organic farming is gaining paramount importance from the recent past. It minimizes environmental pollution by eliminating toxic chemicals and improves the quality of produce besides fetching remunerative price. Thus, farmers are highly passionate and getting attracted for growing organic food. Adopting organic farming is essential for a sustainable future since it ensures the planet's long-term health and the welfare of future generations.However, the inputs used in organic production is purchased from the input dealers at higher prices, as the farmers lack awareness about the eco-friendly products, their ingredients and preparations. Use of biological agents, plant-based extracts, cow-based preparations, microbial consortia, and other similar items are environmentally acceptable and readily available in the local market, which costs very less if prepared by the farmer himself.

1. Introduction

India is an agrarian country, majority of the farmers being small and marginal, they are resource poor and lack awareness about use of eco-friendly products and practices followed in organic production system. With increase in population, more agrochemicals are applied per unit area in order to achieve higher yield. This resulted in serious health problems as well as contamination of the environment. The misconception of utilising more chemicals will result in higher yield was found to be the major reason for falling into debts by the farmers. This is the root cause for alarmingly high suicide incidences among indian farmers. Environmentalists, scientists, policy makers

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and farmers are looking for solution to this issue. Health-conscious consumers were looking for ways to put healthy and chemical free food on their plates. The best option is to return to traditional farming methods. But, the major challenge is how much and how quickly chemical agriculture can be transformed to organic agriculture without lowering the current productivity levels.

In organic agriculture, external chemical inputs are avoided. It largely depends on use of organic products and waste products generated in the agricultural sector as raw materials. However, there are number of drawbacks in organic farming. The main limitation is the low yield. Further, organic agriculture is labour intensive and costly due to lack of availability of various organic inputs. This predicament can be changed if organic producers have access to relevant products and technologies that are used in organic production system to increase yield besides curtailing the cost of cultivation thereby reducing the price of organic products.

2. Nutrient Management under Organic Farming

Organic farming emphasizes use of organic manures like compost (10 t ha^{-1}), animal manure, growing of cover crops (cowpea and horse gram) and green manure crops to nourish the soil and create a harmonious ecosystem within the farm. Most of the organic farmers apply bulky organic manures viz. farm yard manure (FYM) which contain very low amount of nutrients (5 kg N:2 kg P_2O_5:5 kg K_2O per tonne) and takes 4 to 6 weeks of time to release nutrients to meet the nutrient requirement of the crops. But, by enriching FYM with rock phosphate and other natural minerals and also treating FYM with different bio-fertilisers or microbial consortia (combination of different synergistic bio-fertilisers), more nutrients are made available to the crop plants. Added to this, the mineralisation of nutrients becomes rapid and indigenous nutrients available in the soil are easily utilised at the critical periods of crop growth. *Azospirillum, Azotobacter, Azolla*, phosphorus solubilising bacteria, potassium releasing bacteria, zinc solubilizers, pink pigmented facultative methylotrophs (PPFM) etc. are few examples of such effective bio-fertilisers. They help in tolerating environmental stress also.Now a days, liquid bio-fertilisers are also available with prolonged shelf life. Traditional liquid organic manures such as kunapajala, jeevamrutham and panchagavya are also gaining importance where, indigenous cow-based products are used as raw materials for preparation. Green manure crops like *Dhaincha*, *Sunhemp* and others are gaining popularity due to their capacity to add organic matter to the soil and provide a variety of other benefits once incorporated. With the use of bacterial consortia (N, P, K and Zn biofertilizers) appended with bio-enhancers (beejamrutham and jeevamrutham) found higher bacterial population (85% higher over control) and enzymatic activity (urease 55% and dehydrogenase 40% higher over control) in the rhizosphere soil (Veerendra et al., 2022).

2.1. Biofertilizers

Biofertilizers are natural fertilizers that are microbial inoculants of bacteria, algae and fungi (separately or in combination), when applied to seed, plant surfaces or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of nutrients to the host plant. They add nutrients through natural process of nitrogen fixation, solubilizing phosphorus and stimulating plant growth through the synthesis of growth promoting substances. Biofertilizers offer essential nutrients without polluting the soil, also plays important role in regeneration of soil by promoting beneficial microbial activities, thereby improving the soil health. Different biofertilizers used in organic farming are as follows

2.1.1. Rhizobium

Rhizobium is a soil habitat gram negative bacterium (e.g. *Rhizobium*, *Bradyrhizobium*), which can able to colonize the roots and fixes atmospheric nitrogen symbiotically in pulses, leguminous oilseeds and fodder crops. These bacteria are able to convert atmospheric nitrogen into nitrogen compounds to the tune of 72 to 350 kg of nitrogen ha^{-1} $year^{-1}$ (Ismail et al., 2021). The *Rhizobium* biofertilizer improves crop yield by 10–28% (Ismail et al., 2021). It can be applied as a seed treatment with a dosage of 1.0 to 1.25 litre ha^{-1} through liquid formulation.

2.1.2. Azotobacter

Azotobacter is a gram negative, aerobic, free-living bacteria fixes nitrogen non symbiotically. Application of azotobacter biofertilizer provides 15–20 kg nitrogen ha^{-1}. It is recommended for cotton, wheat, maize, jowar, mustard and vegetable crops with a dosage of 1.0 to 1.25 litre ha^{-1} through liquid formulation for seed treatment (Simon, 2022).

2.1.3. Azospirillum

Azospirillum forms associative symbiosis relationship with

plants, it fixes atmospheric nitrogen as well as secretes growth promoting substances like IAA (Indole Acetic Acid), gibberellins. It is recommended for sorghum, millets and wheat. Dosage of 1.0 to 1.25 litre ha^{-1} liquid formulation is applied for seed treatment (Simon, 2022)

2.1.4. Phosphobacteria

Phosphate solubilizing biofertilizers (PSB) contains bacteria (*Pseudomonas striata*, *Bacillus*) that are capable of solubilizing inorganic phosphorous from insoluble compounds and providing it for plant uptake. It is recommended for all crops with a dosage of 1.0 to 1.25 litre ha^{-1} for seed treatment in liquid formulation (Simon, 2022)

2.1.5. Potassium solubilising bacteria

The application of potassium (K) solubilising microorganisms is a promising biofertilizer for increasing K availability in soil. Potassium solubilising bacteria (KSB) solubilizes K-bearing minerals and converts insoluble K to available form. The bacterial species like *Bacillus mucilaginosus*, *B. edaphicus* and *B. circulans* have the ability to solubilize K-minerals like biotite, muscovite,mica, illite and orthoclase. It is applied at dosage of 1.0 to 1.25 litre ha^{-1} in liquid formulation for seed treatment (Simon, 2022).

2.1.6. Azolla

Azolla is an aquatic heterosporous fern which contains an endophytic *cyanobacterium*, *Anabaena azollae,* in its leaf cavity. It is used as a bio-fertilizer for wetland paddy due to its ability to fix nitrogen, it is applied after 1 week of rice transplantation @ 500 kg ha^{-1}.

2.1.7. PPFM

Pink pigmented facultative methylotrophs (PPFMs) are diversified group of microorganisms that promote plant growth by producing indole acetic acid (IAA) and cytokinins. The benefits of application of PPFM to crop plants are it promotes early seed germination, seedling growth, accelerate vegetative growth, increase leaf area index, chlorophyll content, earliness in flowering, fruit set and maturation, improves fruit quality, colour and seed weight, it also contributes in increasing the yield by 10%, and mitigation of drought (Anand Kumar, 2021). PPFM is recommended for all crops, it is applied through seed treatment (Imbibe seed in 1.0% volume for 5–10 min) and foliar spray @ 1% spray during morning or evening at the critical stage of crop growth

2.1.8. VAM

VAM bio-fertilizer also known as vesicular-arbuscular mycorrhiza, is a beneficial soil fungus that forms a symbiotic relationship with plant roots. The fungus enhances plant growth and improves soil health by increasing nutrient uptake, water absorption, and disease resistance. It is recommended to various crops such as cereals, legumes, fruits, and vegetables. It is applied to soil at dosage of 12.5 kg ha^{-1}

2.2. Jeevamrutham

Jeevamrutham acts as a bio-stimulant by promoting the activity of beneficial microorganisms in the soil and also the activity of phyllospheric microorganisms when sprayed on foliage. It acts like a primer for microbial activity and also increases the population of native earthworms. Jeevamrutham is prepared by the unique technique of fermentation of the combined mixture of cow dung, cow urine, jaggery, pulses flour, soil and water. Ingredients required for its preparation are fresh cow dung (10 kg), cow urine (5–10 litres), lime (50 g), jaggery (2 kg), pulse'flour (2 kg), handful of soil and water (200 litres). Jeevamrutham is acidic in nature and good source of primary nutrients (N: 1.97%, P: 0.172%, K: 0.29%) and micro nutrients (Mn: 47 ppm and Cu: 50 ppm) (Kumar et al., 2021). It is applied at the rate of 500 litres ha^{-1} through irrigation water or foliar spray. It can be prepared in one day and shelf life is about 7 days.

2.3. Ghana jeevamrutham

Ghana jeevamrutham is the solid form of jeevamrutham that acts as natural fertilizer for the crop plants. It is prepared using ingredients like indigeneous cow dung (100 kg), cow urine (10 litres), Jaggery (1 kg), pulse flour (1 kg), handful of soil collected either from forest or base of tree. Preparation time is 1 week and it is applied to soil at the dosage of 1000 kg ha^{-1} (Simon, 2022).

Preparation method: Spread the dung on the floor and apply cow urine, jaggery, pulse flour and handful of soil over the dung and mix thoroughly. Then make it into small balls, dry them in shade for one week. After getting dried convert it into powder, store in gunny bags. It has to be used within six months of its preparation as its shelf life is 6 months only.

2.4. Panchagavya

Panchagavya is an organic product having the potential to play the role of promoting growth and providing immunity in plant system. Panchagavya is prepared from mixing of nine products viz. cow dung, cow urine, milk, curd, jaggery, ghee, banana, tender coconut and water. For preparation of panchagavya, 7 kg fresh cow dung and

1 kg ghee are mixed thoroughly and kept for 2 days by stirring daily thrice. After 2 days, add 4 L cow urine+10 L water and is fermented for 10 days by stirring daily twice, then add 2 L of cow milk, 2 L of curd, 3 L of sugarcane juice or 250 g jaggery, 2 L of coconut water and 12 no's of ripened banana and the mixture is allowed to ferment for 15 days by stirring the contents daily at least 2–3 times. The solution is filtered and used as a spray @ 3% during flowering and 15days after flowering.

2.5. Vermicompost

Vermicompost refers to manure prepared using earth worms for decomposition of organic waste (cowdung, crop residue or another farm waste). Earthworms excreta (vermicast) is a nutritive organic fertilizer rich in humus, nitrogen, phosphorus, potash, micronutrients, beneficial soil microbes viz. nitrogen fixing and phosphate solubilizing bacteria and actinomycetes and growth hormones like auxins, gibberlins and cytokinins (Sinha et al., 2010). Vermicompost can be prepared within 50–60 days and it contains 2 to 3 times higher nutrient content compared to farm yard manure.It can be used for all crops such as agricultural, horticultural, ornamental, and vegetables etc. For agricultural crops the vermicompost is applied at dosage of 3–4 t ha^{-1}, whereas for fruit trees it is applied @ 5 kg $tree^{-1}$ and for vegetable crops @ 5 t ha^{-1}.

2.6. Vermiwash

Vermiwash is a liquid extract produced from vermicompost in a medium where earthworms are richly populated. It comprises decomposing bacteria, mucus, vitamins, different bioavailable minerals, hormones, enzymes, different antimicrobial peptides, etc. Besides its application as a fertilizer to enhance crop productivity, also helps in disease suppression and pest control due to the presence of essential antimicrobial and anti pest chemicals. As compared to application of solid vermicompost, its liquid form (vermiwash) is more suitable due to its bioavailability to reach quickly to targeted area around the roots of plants. Vermiwash is used @ 4 to 5 litres ha^{-1} through 10% foliar spray (100 ml per litre of water) for crops during critical stages for supply of nutients, growth promotion and also for disease control.

2.5. Practices for nutrient management under organic farming

• Cover crops (cowpea and horsegram) and mulching with green and dry organic matter for nutrient recycling and for creating a suitable micro-climate for maximum beneficial microbial activity in soil.

• Inclusion of legumes in cropping system

• Managing diversity on farm through integration of tree components

• Integration of livestock, especially of native breed for cow dung and cow urine as essential inputs for several practices.

• Incorporation of crop residues

• Water and moisture conservation practices like mulching and surface management practices

3. Plant Proection under Organic Farming

Organic farming production systems are challenged by crop protection issues as same as in conventional farming systems. In organic farming plant protection is mainly based on the ecosystem services provided by well-maintained and functional biodiversity, as well as preventive measures to be as little dependent on external inputs as possible. As a last resort, organic farmers can use plant protection products but only if they are natural substances.

3.1. Weed management practices under organic farming

In organic farming, weed management is very critical and most of the organic farmers take up hand weeding, which is time consuming and a costly approach. There are other mechanical weeding solutions, such as utilising cono-weeder or rotary weeder in paddy or a star weeder in irrigated dry crops with a narrow spacing. They do not require fuel and need less labour. Taking up weeding operation before the weeds shed seeds could prevent weeds entering into the weed seed bank. Several such measures include, clean cultivation, applying well decomposed FYM and cleaning the implements before taking up any field operation. Using commercial allelopathic chemicals to control weeds is also another option. But they are not much available in local markets. Marketing such products is of prime importance. Soil solarisation is also found to be effective but use of polythene must be avoided in organic practices as they are not easily degradable in nature after use. But mulching with organic material like straw and stubbles applied @ 8 to 10 t ha^{-1} can be taken up to control annual weeds (Teasdale and Mohler, 1993).

3.1.1. Mulching

Use of crop residues as mulch, the weeds find it difficult

to receive enough light to grow and may not be able to pass through the mulch layer. Crop residues or dry, hardy material that decomposes slowly, keeps it effective for longer period than green fresh mulch material.

3.1.2. Intercropping

Intercropping with fast growing weed suppressive species (Smother crop or living mulch) between rows of main crop species is effective in weed control

3.1.3. Crop rotation

Rotation of crops is the efficient measure to regulate seed and vegetatively propagated weeds. Changing the conditions of the crop interrupts the living conditions of the weeds thus inhibiting their growth and spread.

3.1.4. Sowing time and density

Sowing the crop at right time and at recommended spacing provides optimum growing conditions, which enhances the crop plant growth and development and their ability to compete the weeds.

3.2. Eco-friendly products and practices for plant protection

Pest and disease management is another difficult task in organic production systems. Insecticides are one of the most widely used agrochemicals in India, contaminating the environment, water bodies and threatening honey bees too. Managing the ecosystem in organic farming is very challenging. It is made even more complex when factors like insect pests and disease interact. Since the use of synthetic pesticides are prohibited, the cropping systems rely on the prevention of pest outbreaks rather than coping with them after their occurrence. For successful pest management use of a number of control strategies is must. Some of the eco-friendly plant protection products can be effectively used for control of pest and diseases in organic farming systems. Liquid preparations such as agnastram, brahmastram can be used for foliar sprays whereas, beejamrutham can be used for seed treatment which can fight against seed borne fungi. Use of *Trichoderma*, *Bacillus* and *Pseudomonas* formulations@ 5 kg ha^{-1} for soil application help in preventing soil borne fungal and bacterial infestations. Using neem seed kernel extract 5%, tobacco decoction, turmeric etc., can also fight against bacterial and fungal pathogens and they deter the pests from attacking the crop. Use of *Bacillus*, *Metarhizium*, *Beauveria* spp. formulations @ 5 kg ha^{-1} can control insect pests and are easily available in the market also. Adoption of cultural practices like crop rotation, selection of crop plant varieties, timing of planting and harvesting, irrigation management, crop rotation, and use of trap crops (jowar, castor, marigold, napier grass) help reduce populations of insects, mites, and other pests. These cultural practices are more preventive than curative and thus may require planning in advance.

3.2.1. Botanicals

Some plants contain chemical components that are toxic to the pathogens. When extracted from the plant and applied on infested crops, these components are called botanical pesticides or botanicals. Plants have limitless ability to synthesize secondary metabolites, most of which show antimicrobial effect and serves as plant defence mechanisms against pathogenic microorganisms. Important subclasses in this group of compounds include phenols, phenolic acids, flavones, quinones, flavanol's, flavonoids, and tannins. These compounds are synthesized by plants in response to microbial infection and are often found effective in vitro as antimicrobial substance against a wide array of microorganisms. The crude sap, volatile and essential oil extracted from whole plant or specialised plant parts like roots, stem, leaves, flowers, fruits and seeds are widely used in preparing the antimicrobial compounds which are significantly used against the different plant pathogens/diseases.

Table 1: Botanical preparations for pest control

Preparation	Dose	Pest
Leaf extract (Datura, seethapal, tulsi)	2–5%	Leaf feeders like *Spodopteralitura* and leaf webber, aphids
Neem seed kernel extract (NSKE)	3–5%	Aphids, borers, pod fly, leaf miner etc.
Neem oil	2.5%–5%	Sucking pests, leaf miner
Neem cake	250 kg ha^{-1}	Shoot and fruit borer of bhendi, brinjal
Tobacco leaf extract	1% decoction	Soft bodied insects of all kinds (Aphids, jassids, mealybugs, hoppers)

Commonly used botanicals (Table 1) like plant extracts used in crops are found effective in controlling different insects.

Asawalam et al. (2018) evaluated different botanicals (*Ocimum gratissimum, Azadirachta indica, Vernonia amygdalina, Allium sativum, Curcuma longa, Musa paradisiaca* and *Xylopia aethiopica*) 2% solution against different pests in mungbean and found that there is a significant reduction in the mean whitefly population density in *Curcuma longa* treated and a significant increase

in the plant height, test weight and yield was reported.

3.2.2. Beejamrutham

Beejamrutham is an ancient, sustainable agriculture technique. It is used for seeds, seedlings or any planting material. It is effective in protecting young roots from fungus. Beejamrutham is a fermented microbial solution, with loads of plant-beneficial microbes, and is applied as seed treatment. Ingredients needed: cow dung (5 kg), cow urine (5 litres), lime powder (50 g), water (20 litres), handful of soil collected either from forest or base of tree.

Preparation: Take 20 litres of water in small bucket or tank and suspend cow dung in it over night by hanging into water in a cloth, add cow urine, lime and soil into water, allow for fermentation, beejamrutham preparation can be done in 12-14 hrs.

Use of beejamrutham as a seed treatment: Add beejamrutham (10ml-15ml per kg of seed) to the seeds of any crop, coat them, mixing by hand, dry them well and use them for sowing. For leguminous seeds, which may have thin seed coats, just dip them quickly and let them dry and use for sowing.

3.2.3. Agnastram

Agnastram is a natural insecticide prepared from pulp of neem leaves, tobacco powder, green chilli, garlic paste and turmeric powder. It is used to control all sucking pests and caterpillars like leaf roller, stem borer, fruit borer, pod borer etc. This is a natural insecticide prepared from leaves of neem, karanj, custard apple and datura which have specific alkaloids to repel pests. It controls all sucking pests and hidden caterpillars that are present in pods and fruits. It is applied as a foliar spray @ 15–20 litres ha^{-1} in 500 litres of water for control root borer pests, shelf life of prepared product is 3 months only.

3.2.4. Neemastram

It is used to prevent or cure diseases, and kill insects or larvae that eat plant foliage and suck plant sap. This also helps in controlling the reproduction of harmful insects. Neemastram is very easy to prepare and is an effective pest repellent and bio-insecticide for organic farming.

Preparation: 200 litres of water is added to a drum, and cow dung (2 kg), cow urine (5 litres), neem leaf paste (5–10 kg) is also added and the mixture is allowed to fermentate, it takes 3 days for preparation.It is applied as a foliar spray @ 15–20 litres ha^{-1} in 500 litres of water for every 20 days and the helf life of prepared neemastram is 3 months only.

3.2.5. Brahmastram

Brahmastram is used to control all types of fruit borers and sucking pests. For its preparation 20 litres of cow urine is added into a pot and neem leaf paste (2 kg), pongamia leaves (2 kg), custard apple leaves pulp (2 kg), datura leaves pulp (2 kg) and castor leaves pulp (2 kg) are added into a pot and allow to boil for 1 hour on a small flame and allow it tocool for 48 hrs and stir it in the morning and evening. It is applied as a foliar spray @ 15–20 litres ha^{-1} in 500 litres of water, shelf life of the product is 6months.

3.2.6. Dashaparni kashayam

It acts as substitute for neemastram, bramhastram, and agnastram. It is prepared from turmeric powder, ginger paste, *Asafoetida*, tobacco powder, chilly pulp, garlic paste, ginger paste. Leaves of the neem, *Pongamia pinnata*, *Annona sqamosa*, castor, Datura, rui, hibiscus, mango, *Lantana camara*, guava etc can be used. It is used to control all the pests, weeds and even diseases and applied as a foliar spray@ 15 litres ha^{-1} in 500 litres of water, shelf life of the prepared product is 6 months.

4. Conclusion

Use of eco-friendly products plays an important role in reducing cost of cultivation and increasing yield in organic farming. It is necessary to raise awareness about such products and their preparations. Agricultural departments can plan method demonstrations and manufacturers must promote these products across multiple local market places. Farmers will prosper as a result of increased yields, while consumers get benefitted as a result of increased availability of organic products at lower prices.

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