

# Organic Farming:

## An approach for sustainable agriculture

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*Organic farming is a sustainable agriculture production system being followed since ancient times in India. The natural resource management and biodiversity conservation are core principles of organic agriculture. During post independence era, the most important challenge was to produce enough food grain for the growing population. Hence, high-yielding production system with chemical fertilizers and agrochemicals was adopted. The system has concerns related to soil health, agrosphere, environmental pollution, sustainability and productivity. Organic farming is a system of farming that involves growing and nurturing crops without the use of synthetic fertilizers and pesticides. Also, no genetically modified organisms are permitted. The primary aim of organic farming is to keep the soil in good health through the use of biological materials along with beneficial microbes to release macro and micronutrients to crops for increased sustainable production in an ecofriendly, pollution free environment. Organic farming provides quality food and is beneficial to human health and environment.*

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**O**RGANIC farming is an alternative agricultural system which originated early in the 20<sup>th</sup> century in reaction to rapidly changing farming practices. Commercial organic agriculture is now being practiced in more than 170 countries, and is gaining gradual momentum across the world. Highest number of organic producers are in Asia (36%) followed by Africa (29%) and Europe (17%). There is 43.1 Mha of organic agricultural land in India including conversion areas with 2 million producers. Organic farming management is an integrated approach, where all aspects of farming system are interlinked with each other and work for each other. A healthy biologically active soil is vital for crop nutrition; on-farm biodiversity controls pests, crop rotation and multiple cropping maintains the system's health, and on-farm resource management with integration of cattle ensures

productivity and sustainability. According to FAO "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs". Organic farming leads to production of high quality food in sufficient quantity in harmony with natural systems and cycles. This system makes use of organic wastes, and crops are raised in such a manner that it keeps the soil healthy and alive. Microbes are used as bio-fertilizers to increase production without polluting the environment. The key characteristics include protecting the long-term fertility of soil by maintaining organic matter levels, fostering soil biological activity, careful mechanical intervention, nitrogen self-sufficiency

through the use of legumes and biological nitrogen fixation, effective recycling of organic materials including crop residues and livestock wastes and weed, and diseases and pest control relying primarily on crop rotations, natural predators, diversity, organic manuring, and resistant varieties. A great emphasis is placed to maintain the soil fertility by returning all the wastes to it chiefly through compost to minimize the gap between NPK addition and removal from the soil. The key factors affecting consumer demand for organic food is health consciousness and willingness of the public to pay for the high-priced produce. Government policies aim to stimulate the organic sector through subsidies, consumer education, and support in the form of research, education, and marketing.

Agricultural practices of India date back to more than 4000 years, and organic farming is very much native

to this country. As mentioned in *Arthashastra*, farmers in the *Vedic* period possessed a fair knowledge of soil fertility, seed selection, plant protection, sowing seasons, and sustainability of crops. After almost a century of development organic agriculture is now being embraced by the mainstream, and shows great promise commercially, socially and environmentally. While there is continuum of thought from earlier days to the present, the modern organic movement is radically different from its original form. It now has environmental sustainability at its core in addition to concerns for healthy soil, healthy food and healthy people.

### Prospects

India has traditionally been a country of organic agriculture, but the growth of modern scientific, input intensive agriculture has pushed it to wall. With the increasing awareness about the safety and quality of food, long term sustainability of the organic farming system and evidences of being equally productive, organic farming has emerged as an alternative system of farming which not only addresses the quality and sustainability concerns, but also ensures a debt free, profitable livelihood option. Commercial organic agriculture with its rigorous quality assurance system is a new market controlled, consumer-centric agriculture system. During the last 10 years, it has grown at pace of 25-30% per year, world over. Even though the above factors have contributed to the growth of market for organic food, it is interesting to note that there have been no major promotion campaigns in catering organic food. In this context, marketing concepts need to be prominent but cannot dominate totally. The key factor affecting consumer demand for organic food is the health consciousness and the



Organic nutrition garden

willingness of the public to pay for the high-priced produce. India is poised for faster growth with growing domestic market. Success of organic movement in India depends upon the growth of its own domestic markets. The concept of organic farming has strong marketing appeal, growth forecasts are almost all positive and it has been suggested that the 'movement' is now an 'industry'. Organic agriculture is one of the fastest growing agribusiness sectors in the world, with double-digit annual growth in land under organic cultivation, value of organic produce and number of organic farmers. There is about 26 Mha organic farmland currently. National Programme on Organic Production (NPOP) defined its regulatory framework; the National Project on Organic Farming (NPOF) has defined the promotion strategy and provided necessary support for area expansion under certified organic farming. Initial estimates during 2003-04 suggested that approximately 42,000 ha of cultivated land was certified organic. By 2012, India had brought more than 11.2 Mha of land under certification. India has also achieved the status of single largest country in terms of total area under certified organic wild harvest collection.

### Constraints

**Land:** Out of total geographical area of India (328.7 Mha), about 80% (264.5 Mha) is under agriculture, forestry, pasture and biomass production. India supports approximately 16% of the world's human population and 20% of the world's livestock population on merely 2.5% of the world's geographical area. The steady growth of human population coupled with fastpaced developmental activities exerts heavy pressure on India's limited land resource and causes severe land degradation. According to latest estimates, about 184.8 Mha

of land (57% of total land area) has been degraded due to various reasons. Groundwater depletion occurs in regions intensively irrigated by tube wells. The rate of loss of soil organic carbon (SOC) and total nitrogen (TN) in surface soil horizon decreases with cultivation. Over 10.9 Mha of permanent pasture contains 42 animals per hectare for grazing against the threshold level of 5 animals per hectare. Overgrazing and massive extraction of fodder increase compaction and reduce infiltration ultimately changing the soil quality. Most parts around urban and industrial areas are witnessing massive release of solid and liquid waste. In addition, India is witnessing open cast mining in many of its geographical regions with consequent increase in soil pH, Mg : Ca ratio, bulk density, clay dispersibility, total magnesium and calcium carbonate and decrease in soil porosity and available phosphorous.

**Water quality:** According to the National Water Quality Inventor report, compared to the point sources, agricultural non-point sources (NPS) are the leading contributor to water quality degradation of rivers and lakes. Agricultural activities as non-point source of pollution include sedimentation, eutrophication,

salinization through irrigation in arid areas and addition of pesticides and heavy metals to streams, lakes and rivers through runoff. Further, the quantity of fertilizer use, type of farming practices and crop species also affect the groundwater quality. In comparison, nutrient loss to run-off is considerably low from organic farm lands.

**Irrigation:** Industrial and municipal waste waters containing toxic metals such as Zn, Cu, Pb, Mn, Ni, Cr, Cd are increasingly being used for irrigating crops especially in urban and peri-urban areas of developing countries due to easy availability, disposal problems and scarcity of unpolluted fresh waters. Regular irrigation of cropland with sewage and industrial wastewater may cause heavy metal accumulation in soil, degrading soil quality. Plants irrigated with wastewater accumulated 116–378 mg/kg Fe, 12–69 mg/kg Mn, 5.2–16.8 mg/kg Cu and 22–46 mg/kg Zn. In a study at Varanasi, continuous application of treated wastewater was found to cause accumulation of Cd (1.55–13.80 µg/g), Pb and Ni (10.45–39.25 µg/g) exceeding their safe limits for heavy metal contamination of Ganges, the major river system of north India.

**Atmospheric deposition:** Atmospheric deposition of pollutant aerosols is rising in many parts of the world including India. Atmospheric deposition of toxic metals could affect human health and plant performance directly or through soil and food chain associated routes. Deposition of heavy metals not only leads to multifold accumulation in tomato, eggplant, spinach, amaranthus, carrot and radish but also cause significant damage to soil microbial activity in organically amended soil. Thus, deposition of heavy metals may compromise organic farming's ability of stabilizing soil fertility and providing toxin-free produce.

**Livestock resources:** Livestock resources have played multifaceted roles strengthening indigenous agricultural practices and generating income and livelihoods for large masses of rural dwellers in India.

However, with the advent of technology in agriculture, livestock population in our country is rapidly declining. Advent of technology in agriculture coupled with inadequate feed supply is the major determinant reducing attraction of common people towards livestock production, and thus the availability of manure even to small farm. The area under natural pasture in India is rapidly declining as a result of expanding urban and agricultural areas. For maintaining soil fertility and meeting crop nutrient demands, large quantity of organic supplements are needed and accordingly, appropriate farmscale management strategies considering cultural and socio-economic environment of farmholders are required. In particular, lack of sufficient amount of vermicompost and non-availability of biofertilizers in local market further constrain organic producers. In India, most of the crop residues are removed from the fields for use as fodder and fuel. Thus, adoption of mulch farming technique as a potential tool to conserve soil organic matter content to sustain biomass/agronomic yield is possible if cost effective alternate sources of fodder and fuel are identified and made available at large scale.

**Certification:** Access to certification, cost involved and a time lag of three years (conversion stage) often constrain farmers especially small land holders in India from adopting organic farming. Organic produce needs certification to ensure that all synthetic inputs are prohibited and soil building approaches are followed. The certification process aims at converting the growing area to comply with requirements of standard within a period of three years. For this reason, farmers who adopt organic management need to wait for up to three years under certification procedures that requires purging of chemical residues. In India, the Director General of Foreign Trade, New Delhi, permits the export of organic produce provided that these are produced, processed and packed under a valid organic certificate issued by a

certification agency accredited by an accreditation agency designated by the Government of India. The Government of India has recognized Tamil Nadu Organic Certification Department, Agricultural and Processed Food Products Export Development Authority (APEDA), Spice Board, Ministry of Commerce and Industry, Coffee Board and Tea Board for the purpose. However, lack of knowledge, rationale capital and access to certification discourage small holders in developing countries including India. There may be a deficit in net income under organic farming compared to conventional one up to third year. As input cost declines, the net income increases progressively fourth year onward. However, the initial three year deficit coupled with certification associated constraints often make small holders apprehensive.

### Opportunities

A substantial amount of CO<sub>2</sub> comes from soil through decomposition, mineralization and soil respiration. Conventional agricultural practices that most often accelerate these processes can substantially influence atmospheric C balance on global scale. The mechanism and potential of C-sequestration in converted ecosystems are still not well understood and probably for this reason, predictions made for global carbon balance remain uncertain. The soil C pool reflects a balance between the input and output, and if the carbon flux is low relative to storage it leads to sequestration in soil but a higher flux causes C loss. Soil carbon sequestration holds the greatest global C mitigation potential. Most agricultural soils have lost 30–70% of their antecedent SOC pool. Soil carbon sequestration is cost effective and may contribute to about 89% of total C mitigation. India, representing almost all major climatic zones and wide range of land use systems, has vast opportunities for soil carbon sequestration. Conversion from natural to agricultural ecosystem causes depletion of SOC pool by 60% in soils of temperate regions and over 75% in cultivated soils. Since the soil

C can have a stable and long residence time, even hundreds to thousands of years under many circumstances, the conversion of plant sequestered C to soil organic C could play a crucial role. The major determinants regulating C-flux or storage in soil include climate (especially temperature), soil moisture, microbial biomass and quantity and quality of natural and added organic inputs. Although the major goal of any agricultural practice is to enhance crop yield, recent global attention has focus to link agricultural management strategies with C-sequestration and sustainability of agro-ecosystems. Sequestration of C may be in the form of soil organic carbon (SOC) and soil inorganic carbon (SIC). Common recommended management practices (RMPs) include mulch farming, conservation tillage, agro-forestry, diverse and intercropping systems, crop rotation, cover crops, and integrated nutrient management including the use of manure, compost, bio solids, improved grazing, and forest management. Further, many agricultural activities enhance GHG emissions. Rice is an important crop in India constituting over 42.5% of the area under cereal cultivation. Rice is cultivated under flooded condition and the anaerobic condition created during rice cultivation leads to emission of CH<sub>4</sub> and N<sub>2</sub>O. A recent study conducted in Punjab indicated that organic amendment can significantly reduce methane emission from rice field.

Employment opportunities is one of the major issues of developing countries. Organic farming requires over 15% more labour than traditional farming and therefore provides rural job opportunities. Some of the commonly used organic farming techniques such as strip farming, non-chemical weeding, and production, collection and transportation of organic supplements all requires significant labour. The labour scarcity and cost involved therein, may constrain adoption of organic farming in developed countries and also for cash-poor farmers in developing countries. However, for countries like

India, labour as well as the cost involved therein is not a constraint. Instead, organic farming can generate employment opportunity for a vast section of rural communities.

### Strategies

A live, healthy soil with proper cropping patterns, crop residue management and effective crop rotation can sustain optimum productivity over the years, without any loss in fertility. A living soil can be maintained by continuous incorporation of crop and weed biomass, use of animal dung, urine-based manures (FYM, NADEP, vermicompost), biofertilisers and bio enhancers, special liquid formulations (like vermin wash, compost tea etc.). Important components of organic farming are crop rotation, use of crop residue, biological nitrogen fixation, biopesticides, biogas slurry etc.

#### Multiple cropping and 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 insects, weed and diseases. Mix cropping is the outstanding feature of organic farming in which variety of crops are grown simultaneously or at different time on the same land. In every season care should be taken to maintain legume cropping at least 40%. Mix cropping promotes photosynthesis and reduces the competition for nutrients because different plants draw their nutrients from different depth of soil. The legumes fix atmospheric nitrogen and make it available for companion or succeeding crops. Deep rooted plants draw nutrients from deeper layer of soil and bring them to the surface of soil through their leaf fall. All high nutrient demanding crops should precede and follow legume dominated crop combination. Rotation of pest host and non pest host crops helps in controlling soil borne diseases and pests. It also helps in controlling weeds. Crop rotation is the backbone of organic farming practices. To keep the soil healthy and to allow working of natural microbial systems, crop rotation is a must.

#### Manuring and soil enrichment

India has a great potential of using residues of crops and straw of cereals and pulses for recycling nutrients in organic farming. Crop residues when inoculated with fungal species improve physicochemical properties of soil and crop yields. During conversion period, soil fertility can be improved and maintained initially through use of organic inputs like well decomposed organic manure/vermicompost, green manure and biofertilizers in appropriate quantity. Plant biomass, FYM, cattle dung manure, enriched compost, bio dynamic compost, cow-pat-pit compost are key sources of on-farm inputs. Among off-farm inputs, important components are non-edible oil cakes, poultry manure, biofertilizers, mineral grade rock phosphate and lime etc.

**Organic manure:** It 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 by promoting soil productivity by increasing availability of major and minor plant nutrients through soil microorganisms.

Bulky organic manure includes compost, FYM and green manure having less nutrients in comparison to concentrated organic manure. Large quantities of waste material (vegetable refuse, weeds, stubble, straw, sugarcane trash, sewage, sludge, animal waste, human and industrial refuse) can be converted into compost by an aerobic decomposition. Farm Yard Manure (FYM) refers to the well decomposed combination of dung, urine, farm litter and leftover materials (roughages or fodder). Green manuring is the practice of adding organic matter to the soil by incorporating undecomposed green plant tissues for improving soil health. The green manure crop (legumes) supplies organic matter and additional nitrogen. Commonly used green manure crops are sunhemp (*Crotalaria juncea*), dhaincha (*Sesbania aculeata*), cowpea, cluster bean, senji (*Melilotus parviflora*, *Vigna sinensis*), berseem

(*Trifolium alexandrinum*) etc.

**Vermicompost:** Vermicompost is organic manure or compost produced by the use of earthworms that generally live in soil, eat organic matter and excrete it in digested form. It is rich in macro and micronutrients, growth hormones and immobilized micro flora essential for plant growth.

**Concentrated organic manure:** Oilcakes, blood meal, fishmeal, meat meal, and horn and hoof meal are organic in nature. These are made from raw materials of animal or plant origin, and contain higher percentage of vital plant nutrients as compared to bulky organic manures.

**Biofertilizers:** Biofertilizers are microorganisms that have the capability of increasing the fertility of soil by fixing atmospheric nitrogen and phosphate solubilization. Biofertilizers, viz. *Rhizobium*, *Azotobacter*, *Azospirillum*, PSB and *Pseudomonas* etc. have been found to be very effective tools of fertility management and biological nutrient mobilization. Recently, customized consortia of such biofertilizer organisms, better adapted to local climatic conditions have also been developed and are available commercially. Efficiency of such microbial formulations is much higher under no-chemical use situations, therefore, application of such inputs needs to be ensured under all cropping situations. Some important and widely used bio-fertilizers are given here.

*Rhizobium*, *Frankia* and *Anabaena azollae* fix atmospheric nitrogen in roots of leguminous plants, form tumour like growth known as root nodules. These are widely used biofertilizers which can fix around 100-300 kg N/ha in one crop season. Blue Green Algae, *Azolla*, *Azotobacter*, *Azospirillum*, *Beijerinckia*, *Clostridium*, *Klebsiella*, *Anabaena* and *Nostoc* grow on decomposing soil organic matter and fix atmospheric nitrogen in suitable soil medium. *Azotobacter* has beneficial effect on vegetables, millets, cereals, sugarcane and cotton. *Azospirillum* has beneficial effect on oats, barley, maize, sorghum, forage crop and pearl millet. It fixes nitrogen by colonising root zones. *Bacillus*

*megaterium* var. *phosphaticum*, *Bacillus subtilis*, *Bacillus circulans* and *Pseudomonas striata* are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds.

Phosphorus solubilization ability of rhizosphere microorganisms is considered important in plant phosphate nutrition. Fungi like *Penicillium*, *Aspergillus awamori* and *Fusarium* play a noteworthy role in increasing the bioavailability of soil phosphates for plant nutrition.

Arbuscular mycorrhiza like *Glomus* sp., *Gigaspora* sp., *Acaulospora* sp., *Scutellospora* sp. and *Sclerocystis* sp., *Ericoid mycorrhizae*-*Pezizella* sp., *Ectomycorrhiza*-*Laccaria* sp., *Pisolithus* sp., *Boletus* sp., *Amanita* sp. and Orchid mycorrhiza-*Rhizoctonia solani* are phosphate solubilizing microorganisms (PSM) that can play an important role in phosphorus nutrition in many natural and agro-ecosystems. Silicate and zinc solubilizers like *Bacillus* sp. along with recommended dose of major nutrients increases the availability of the essential nutrients in the rhizosphere zone.

*Pseudomonas fluorescens* is known to enhance plant growth and reduce severity of various diseases. The efficacy of bacterial antagonists in controlling fungal diseases was often better as alone, and sometimes in combination with fungicides.

Blue-green algae reduce soil alkalinity and it is good for rice cultivation and bio-reclamation of land.

The process of preparing various cow dung, cow urine filtrates has been described here. These filtrates enrich the soil.

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

**Sanjivak:** Mix 100 kg cow dung, 100 litre cow urine and 500 g jaggary

in 300 litre of water in a 500 litre closed drum. Ferment for 10 days. Dilute with 20 times water and sprinkle in one acre either as soil spray or along with irrigation water.

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

**Amritpani:** Mix 10 kg cow dung with 500 g honey and mix thoroughly to make a creamy paste. Add 250 g of cow desi ghee and mix at high speed. Dilute with 200 litre water and sprinkle this suspension in one acre over soil or with irrigation water. Apply second dose after 30 days in between the row of plants or through irrigation water.

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

**Enriched Panchgavya (or Dashagavya):** Ingredients - cow dung 5 kg, cow urine 3 litre, cow milk 2 litre, curd 2 litre, cow deshi ghee 1 kg, sugarcane juice 3 litre, tender coconut water 3 litre, banana paste of 12 fruits and toddy or grape juice 2 litre. Mix cow dung and ghee in a container and ferment for 3 days with intermittent stirring. Add rest of the ingredients on the fourth day and ferment for 15 days with stirring twice daily. The formulation will be ready in 18 days. Sugarcane juice can be replaced with 500 jaggery in 3 litre water. In case of non-availability of toddy or grape juice 100 g yeast powder mixed with 100 g jaggery and 2 litre of warm water can also be used. For foliar spray 3-4 litre panchgavya is diluted with 100 litre water. For soil application 50 litre panchgavya is sufficient for one ha. It can also be used for seed treatment.

#### Weed management

Weed growth is blocked using plastic films and the process is known

as mulching. Mowing and cutting removes the top growth of weeds. Grazing is another method which helps in reducing weed growth. Organic farmers integrate cultural, biological, mechanical, physical and chemical tactics to manage weeds without synthetic herbicides. Organic standards require rotation of annual crops, meaning that a single crop cannot be grown in the same location without a different, intervening crop.

#### Pest management

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

**Cultural alternative:** Use of disease free seed or stock and resistant varieties are best preventive practices in organic pest management. Maintenance of biodiversity, effective crop rotation, multiple cropping, habitat manipulation and use of trap crops are also effective practices which can keep the population of pests below economical threshold limit (ETL). In the border of the main crop, different natural enemy attracting crops like marigold/other yellow colored flowers ornamental crops, should be planted and synchronized with the main crop. The crop like coriander in gram, mustard, can also be planted in order to promote and conserve the natural enemies. Proper plant spacing and alley planting of the crops should be done with a proper gap between rows and plants. After every 2-3 meter plantings of the main crop a gap of 0.75-1.00 meter should be practiced.

**Mechanical alternative:** Removal of affected plants and plant parts, collection and destruction of egg masses and larvae, installation of bird perches, light traps, sticky coloured plates and pheromone traps are most effective mechanical methods of pest control (Table 1). Light trap is for all nocturnal flying insects: 1 trap/ha (60 watt CFL). Sticky trap yellow is for the

Table 1. Management of Pests by Mechanical methods

| Insect                        | Lure   | Crop                          | Time of installation                                       |
|-------------------------------|--------|-------------------------------|------------------------------------------------------------|
| Rice stem borer               | Scirpo | Rice                          | One week after transplanting. End of tillering stage       |
| <i>Helicoverpa armigera</i>   | Helli  | Gram and different crop       | 25 days after sowing. At flower initiation.                |
| <i>Spodoptera litura</i>      | Spodo  | Different crops               | One week after transplanting. Three weeks after sowing.    |
| Spotted bollworm              | Ervit  | Okra and Cucurbitaceous crops | One week after transplanting. One week prior to flowering. |
| Diamondback moth              | DBM    | Cole crops                    | One week after transplanting.                              |
| Brinjal Shoot and fruit borer | Leucin | Brinjal                       | One week after transplanting. One week prior to flowering. |
| Fruit fly                     | Bador  | Mango, Guava, Litchi          | Prior to flowering.                                        |
| Melon fly                     | Baku   | Cucurbitaceous crop           | One week prior to flowering.                               |

monitoring of aphid, jassid, like insects. 1 trap/100 m<sup>2</sup> area. Sticky trap blue is for the monitoring of thrips like insects. 1 trap/100 m<sup>2</sup> area. Votta T trap is used for Brinjal shoot and fruit borer, Pin moth. For the monitoring 10 traps/ha and for the management 25 traps/ha are used. Pheromone trap is a general tool which is mostly used for lepidopteran insects, it causes damage at larval stages. For the management of adult stage of different species of Lepidoptera insect sex pheromones available in the market can be used.

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

**Bio-pesticide:** Biopesticides are of plant origin and include plant products like alkaloids, phenolics, terpenoids and some secondary chemicals. They are biologically active against insects, fungi, nematodes affecting their behavior and physiology. Commonly known insecticides are Pyrethrum, Nicotine, Neem, Margosa, Rotenone etc. *Trichoderma virideae* or *T. harazianum* or *Pseudomonas fluorescence*

formulation @ 4 g/kg seed either alone or in combination, manage most of the seed borne and soil borne diseases. There are other formulations viz. *Beauveria bassiana*, *Metarhizium anisopliae*, *Verticillium* sp. which are available in the market and can manage their specific host pest. *Bacillus thuringiensis tenebrionis* and *Bacillus thuringiensis sandigo* are effective against coleopterans as well as some other insect species (Table 2). Bt has been used in the management of diamondback moth on crucifers and vegetables @0.5-1.0 kg/ha. Viral biopesticides of baculovirus group, viz. granulosis viruses (GV) and nucleopolyhedrosis viruses provided a great scope in plant protection field. Spray of nuclear polyhedrosis viruses (NPV) of *Helicoverpa armigera* (H) or *Spodoptera litura* (S) @250 larval equivalents are very effective tools to manage the *Helicoverpa* sp. or *Spodoptera* sp. respectively. *Verticillium lecanii* powder (10<sup>7</sup>cfu/gram) 2.5 kg should be dissolved in 500 lit of water for per hectare and should be sprayed. As liquid (10<sup>10</sup>-10<sup>12</sup> cfu/ml) 1000-1250 ml should be dissolved in 500 lit of water and then sprayed for the management of mites and insects like green hopper, leaf miner, thrips, whitefly, brown hopper and other insects. *Beauveria bassiana* powder (1×10<sup>8</sup> cfu/g) 2.5 kg should be dissolved in 500 lit of water for per hectare and should be sprayed. As liquid (1×10<sup>10</sup>-1×10<sup>12</sup> cfu/ml) 1000-1250 ml should be dissolved in

Table 2. Management of pests and weeds through biological agents

| Crop                          | Major pest                                                                                                                                | Eco-friendly management through biological agents                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chickpea/ Pigeon Pea/Lathyrus | <i>Helicoverpa armigera</i> Hubner (Lepidoptera: Noctuidae)                                                                               | Application of <i>Bacillus thuringiensis</i> Kurstaki 8L @ 1.6 kg per ha. and <i>Bacillus thuringiensis</i> Kurstaki ES @ 1.5 lt per ha, respectively, at early stages of crop infestation (1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> instar larval infestation) with at least 2 applications at 7 days interval.                                                                                                                                                                                                               |
| Mustard/ Safflower            | Aphids ( <i>Lipaphis erysimi</i> )                                                                                                        | <i>Cheilomenes sexmaculata</i> Fabricius 5000 larvae or 500 adults per ha, <i>Coccinella septempunctata</i> . 5000 larvae or 500 adults per ha. Two releases: first release to coincide with the appearance of aphids.                                                                                                                                                                                                                                                                                                                      |
| Sunflower                     | Aphid ( <i>Lipaphis erysimi</i> ).                                                                                                        | <i>Chrysoperla carnea</i> (Stephens) 10,000 first instar larvae per ha.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Brinjal                       | Fruit and shoot borer ( <i>Leucinodes orbonalis</i> )                                                                                     | <i>Bacillus thuringiensis</i> 500 g ai per ha (10 days interval). 3-4 releases of egg parasite, <i>T. chilonis</i> @1.0 lakh per ha                                                                                                                                                                                                                                                                                                                                                                                                         |
| Cucurbitaceous                | Fruitfly ( <i>Bactrocera cucurbitae</i> )                                                                                                 | Poison bait: Mix Ethyl alcohol-60 ml + Methyl eugenol-40 ml + Malathion/ DDVP (Pesticide)- 20 ml (i.e. in the ratio of 6:4:2).                                                                                                                                                                                                                                                                                                                                                                                                              |
| Okra                          | Aphids( <i>Lipaphis erysimi</i> )<br>Shoot and fruit borer ( <i>Earias vittella</i> )<br>Fruit borer ( <i>H. armigera</i> )<br>Okra aphid | <i>Cheilomenes sexmaculata</i> Fabricius 5000 larvae or 500 adults per ha,<br><i>Trichogramma brassiliensis</i> 2,50,000 parasitized eggs per ha (Inundative release), 50,000 parasitized eggs per ha (Weekly inoculative release), <i>Bacillus thuringiensis</i> 500 g ai per ha (10 days interval)                                                                                                                                                                                                                                        |
| Tomato                        | Fruit borer ( <i>Helicoverpa armigera</i> )                                                                                               | <i>Chrysoperla zastrowi arabica</i> 50,000 first instar larvae/ha (weekly release)<br><i>Trichogramma brassiliensis</i> 2,50,000 parasitized eggs per ha (Inundative release), 50,000 parasitized eggs per ha (Weekly inoculative release), <i>Bacillus thuringiensis</i> 500 g ai per ha (10 days interval), HaNPV @ 250 lt per ha (10 days interval)                                                                                                                                                                                      |
| Onion                         | Thrips                                                                                                                                    | <i>Xylocoris</i> , <i>Blaptostethus</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Potato                        | Potato tuber moth ( <i>Phthorimaea operculella</i> )                                                                                      | <i>Chelonus blackburnii</i> 50,000 adults per ha in the field. Two releases at weekly intervals. 2 adults per kg of potatoes in godowns.                                                                                                                                                                                                                                                                                                                                                                                                    |
| Colocasia                     | Armyworm<br><i>Spodoptera litura</i> (Fabricius)                                                                                          | <i>Trichogramma</i> spp.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Cabbage                       | DBM ( <i>Plutella xylostella</i> )<br>Cabbage aphid                                                                                       | <i>Bacillus thuringiensis</i> 500 g ai per ha (10 days interval).<br><i>Chrysoperla zastrowi arabica</i> 50,000 first instar larvae/ha (weekly release).                                                                                                                                                                                                                                                                                                                                                                                    |
| Weeds                         | Congress grass weed ( <i>Parthenium hysterophorus</i> L.)                                                                                 | <i>Zygogramma bicolorata</i> Pallister, one adult was found to bring defoliation of a single parthenium plant in 6-8 weeks. Therefore, if releases are to be carried out at this rate, about 0.4. to 0.7 million insects will be required per hectare, as the weed density varies between 40 to 70 plants per square metre. In practice, it is neither possible nor necessary to release so many insects as they are capable of multiplying rapidly. Releases of about 500-1000 beetles can bring about establishment and eventual control. |

500 lit of water for per hectare and then sprayed. For the areas affected by white grubs mainly for the crop the citrus, mango and coconuts etc. 5 ml of *Beauveria bassiana* per lit water must be applied. *Beauveria bassiana* @ 2 kg should be mixed with 200 lit water dispensed through the drip or drench system to control the grubs. It can be applied on the crops like banana, soybean, paddy, oilseeds, tomato, chilli, potato, maize, sugarcane, turmeric, citrus crop, onion, garlic, floriculture and horticulture crops.

**Botanical pesticides:** Many plants are known to have pesticidal properties and the extract can be used in the management of pests. Among various plants identified for the purpose, neem has been found to be most effective. Neem has been found to be effective in the management of approximately 200 insects, pests and nematodes. Neem extracts are very effective against grasshoppers, leaf hoppers, leaf minor, plant hoppers,

aphids, cotton jassids, and moth caterpillars. Neem is also very effective against beetle larvae, butterfly, aphids and white flies, mealy bug, scale insects, adult bugs, diamond back moth. fruit maggots, spider mites, moth and caterpillars such as Mexican bean beetle and Colorado potato beetle. Neem oil @ 2.0% with 1% detergent found most effective against pod borers complex in chickpea, moong, cowpea and okra, shoot and fruit borer of brinjal. Neem seed kernel extract (NSKE) @ 5% with 1% detergent found most effective against stem borer in rice and management of diamond back moth.

Preparation of Neemastra and Agniastra along with other extracts is described here. These are highly effective for pest management.

**Neemastra:** 200 litre water + 10 litre cow urine (Desi) + 2 kg cow dung + 10 kg neem twigs with leaves + 500 g turmeric powder + 500 g ginger paste + 10 g asafoetida (hing)

powder mix it thoroughly and stir with wooden stick clockwise. Keep solution 48 hours in shade then filter the solution. This solution should be sprayed directly on the crop without dilution it controls sucking insects.

**Agniastra:** 20 litre cow urine (Desi) + 2 kg neem leaves (chatani) + 500 g tobacco powder + 500 g hot chilli (chatani) + 250 g desi garlic (chatani) mix this thoroughly and in a low temperature boil it, after boiling keep the solution for 48 hours under shade stir it morning and evening, filter the solution with a cloth and store it. Three litre of extract should be dissolved in 100 litre water and it can be sprayed in general against all sorts of insects.

**Dashparni extract:** Crush neem leaves 5.0 kg, *Vitex negundo* leaves 2.0 kg, *Aristolochia* leaves 2.0 kg, Papaya (*Carica papaya*) 2.0 kg, *Tinospora cordifolia* leaves 2.0 kg, *Annona squamosa* (Custard apple) leaves 2.0 kg, *Pongamia pinnata* (Karanj) leaves 2.0 kg, *Ricinus*

*communis* (Castor) leaves 2.0 kg, *Nerium indicum* 2.0 kg, *Calotropis procera* leaves 2.0 kg, Green chilli paste 2.0 kg, Garlic paste 250 g, Cow dung 3.0 kg and Cow Urine 5.0 lit in 200 litre water ferment for one month. Shake regularly three times a day clockwise. Extract after crushing and filtering. The extract can be stored up to 6 months and is sufficient for one acre. Karanj oil @2.0% with 1% detergent is most effective against pod borer complex in chickpea, moong, cowpea and okra shoot and fruit borer.

**Neem-Cow urine extract:** Crush 5.0 kg neem leaves in water, add 5.0 litre cow urine and 2.0 kg cow dung, ferment for 24 hours with intermittent stirring, filter squeeze the extract and dilute to 100 litre, use as foliar spray over one acre. Most effective against sucking pests and mealy bugs.

**Mixed leaves extract:** Crush 3.0 kg neem leaves in 10 litre cow urine. Crush 2.0 kg custard apple leaf, 2.0 kg papaya leaf, 2.0 kg pomegranate leaves, 2.0 kg guava leaves in water. Mix the two and boil 5 times at some interval till it becomes half. Keep for 24 hours, then filter squeeze the extract. This can be stored in bottles for 6 months. Dilute 2-2.5 litre of this extract to 100 litre for 1 acre. Most effective against sucking pests, pod borer and fruit borers.

**Chilli-garlic extract:** Crush 1.0 kg Ipomea leaves, 500 g hot chilli, 500 g garlic and 5.0 kg neem leaves in 10 litre cow urine. Boil the suspension 5 times till it becomes half. Filter squeeze the extract and store in glass or plastic bottles. Dilution of 2-3 litre extract in 100 litre water is used for one acre. Chilli garlic extract @ 9 kg/ha (8:1) most effective against gall midge, green leaf hopper (GLH), thrips, white fly,

semilooper, shoot and fruit borer of brinjal/tomato and tobacco caterpillar of soybean.

**Broad spectrum formulation:** In a copper container mix 3.0 kg fresh crushed neem leaves and 1.0 kg neem seed kernel powder with 10 litre of cow urine. Seal the container and allow the suspension to ferment for 10 days. After 10 days boil the suspension, till the volume is reduced to half. Grind 500 g green chillies in 1 litre of water and keep overnight. In another container crush 250 g of garlic in water and keep overnight. Mix thoroughly and filter the boiled Chilli-garlic extract. This is a broad spectrum pesticide and can be used on all crops against wide variety of insects. Dilution of 250 ml in 15 litre of water for spray.

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

**Fermented curd water:** In some parts of central India fermented curd water (butter milk or *Chhaach*) is also used for the management of white fly, jassids, greyaphids etc.

#### Certification system

In India, there are two accreditation systems for authorizing Certification and Inspection agencies for organic certification. National Programme on Organic Production (NPOP) promoted by Ministry of Commerce is the core programme which governs and defines the standards and implementing procedures. National Accreditation Body (NAB) is the apex decision making body. Certification and Inspection agencies accredited by NAB are authorized to undertake certification process. The NPOP notified under Foreign Trade

Development and Regulation (FTDR) act, 1992 and controlled by Agricultural Processed Foods Export Development Authority (APEDA) looks after the requirement of export while NPOP notified under APGMC act and controlled by Agriculture Marketing Advisor, Directorate of Marketing and Inspection looks after domestic certification. Authorized certification agencies to undertake certification process are available at [www.apeda.com/npop](http://www.apeda.com/npop). In 2006, India's organic certification process under NPOP has been granted equivalence with European Union and Switzerland. It has also been recognized for conformity assessment by USDA's NOP.

#### SUMMARY

Organic farming provides quality food products and fibers which are beneficial to human health without adversely affecting soil health and environment. Organic farming is a way to keep the soil alive and in good health through the use of biological wastes and other biological materials along with beneficial microbes to release plant nutrients (macronutrients and micronutrients) to crops for increased sustainable production in an ecofriendly, pollution free environment. There is a need to identify suitable crops/products on agro climatic zone basis as conventional farming is shifting its way towards organic farming. Some agro climatic zones have great potential for organic farming and many products can be produced organically. Trading is a major constraint in organic farming due to policy issues. Organic farming can provide ample opportunities for employment.

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#### Organic farming packages and models

Organic farming packages for 4 cropping systems suitable to Gujarat, Kerala, Rajasthan, Sikkim and Uttarakhand were developed as per National Programme for Organic Production (NPOP) standards. Groundnut-wheat-green gram system registered 6.1 t/ha of groundnut equivalent yield with ₹ 1.43 lakh/ha as net returns while cassava-groundnut system in Kerala resulted in cassava tuber equivalent yield of 32 t/ha under organic production system. Fennel-cluster bean system recorded fennel equivalent yield 2.2 t/ha with net income and B:C ratio of ₹ 75,808/ha and 2.21 respectively. Under Sikkim conditions, maize + ginger – French bean resulted in 15 t/ha of maize equivalent yield with net return of ₹ 2.99 lakh/ha.

Source: ICAR Annual Report (2020)