NATURAL RESOURCE MANAGEMENT AND BIO-DIVERSITY CONSERVATION

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Organic farming has emerged in response to questions on the environment, sustainability and human health. Driven-by the principles of circular causation, this farm practice reduces energy dependence and enhances soil fertility stability, carbon sequestration and biodiversity of microbes, plants and animals. To up-scale with ground realities, there is a pressing need for more system level and long-term studies exploring major opportunities and constraints in organic farming in the Indian context.

Driven by the continuous increase in the food demand by the rapidly growing human population under limited agricultural land, excess application of synthetic fertilizers coupled with mechanical soil disturbances led to a continuous loss of soil fertility, deterioration in food quality, increase in water pollution and generation of resistant pests. These have forced the scientists to explore possibilities for opting 'organic farming' as a holistic production management system supportive to the environment, health and agricultural sustainability. The high input production system is unsustainable, says M.S. Swaminathan; advocating towards the need for an ecologically, socially and economically sustainable production system, he named it as the 'evergreen revolution' (Kesavan and Swaminathan, 2018). Organic farming is based on the principle of circular causation with emphasis on the use of organic supplements for enhancing soil quality, minimizing food associated health risks and establishing a closed nutrient cycle to ensure the sustainability of agro-ecosystems (Pandey and Singh, 2012).

Organic farming although yields a bit lesser (10-15%) than the conventional farming, the lower yields are compensated by lower input costs and relatively higher profit margins. Organic farming is now being practiced in over 130 countries covering a total area of ₹30.4 million hectares, 0.65% of the world's total agricultural land. India, although occupies the second place with respect to the number of certified farms (44,926), comes at 13th position for the area under organic agriculture. In India, ₹528,171 ha area is under organic farming accounting for ₹0.3% of total agricultural land. Organic farming industry in India is entirely export-oriented, running as a contract farming system under a financial agreement with the firms.

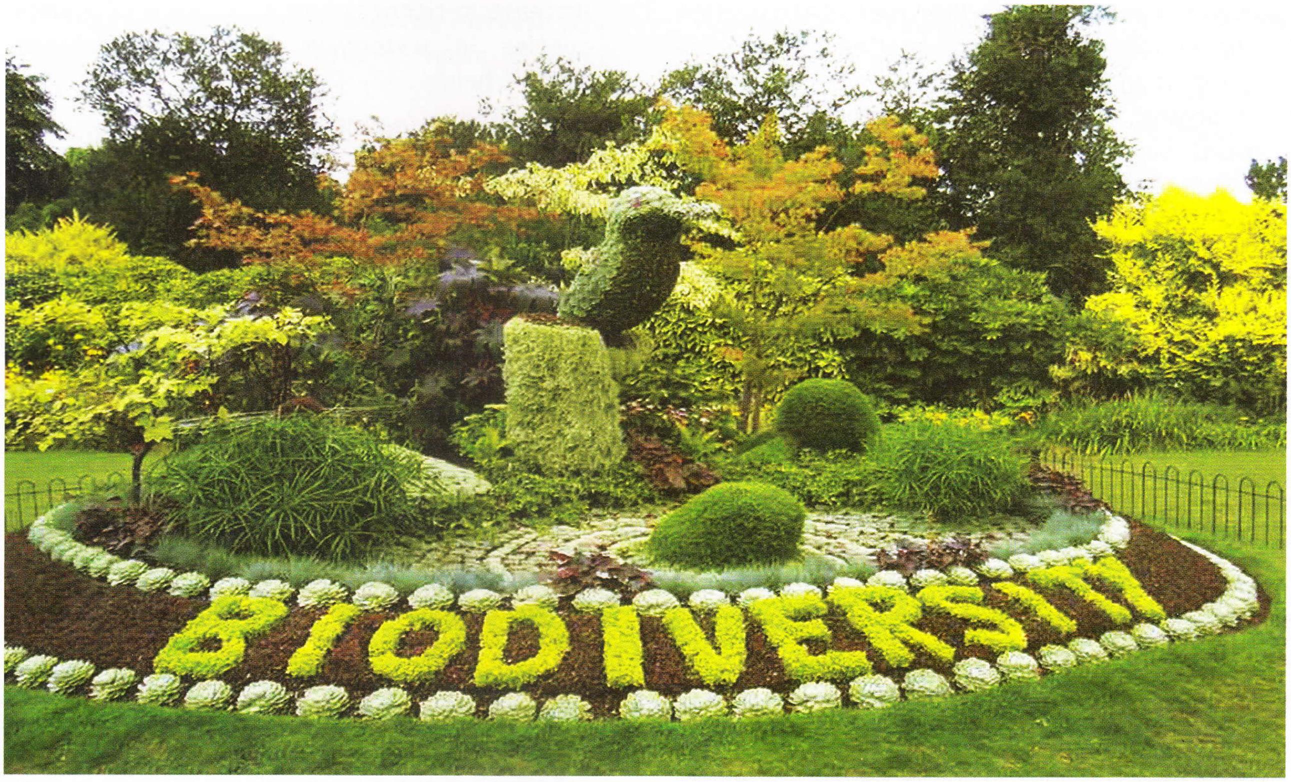
Opportunities in organic farming

A. Conservation perspectives

Organic farming practices are ecologically sustainable in terms of (1) soil fertility stability, (2) increased diversity of microbes, plants and animals, (3) increased carbon sequestration and, (4) reduced energy dependence.

(1) Soil fertility stability

The degraded soil quality is an important constraint in agricultural productivity in our country. Despite continuous use of synthetic fertilizers, driven



by soil quality degradation and nutrient mining, the agricultural productivity in India reduced from about 234.5 million tons in 2008-09 to about 218.2 million tons in 2009-10. In conventional agriculture, soil fertility declines with crop harvest. For this reason, global fertilizer use increased from ~27.4 million tons (1959-60) to 143 million tons (1989-90) and likely to reach to 208.0 million tons by the year 2020. Despite that, the world's cereal yield growth has declined from an annual average of 2.2% in the 1970s to 1.1% in the 1990s. The organic farm practices help to restore long-term soil quality. One acre of living topsoil contains ~900 pounds of earthworms, ~2,400 pounds of fungi, ~1,500 pounds of bacteria, ~133 pounds of protozoa and ~890 pounds of arthropods and algae (Pimentel *et al.,* 2005). Organic supplements are easily colonized by microorganisms that help to stabilize soil fertility via improving decomposition, nitrogen fixation and reducing the losses of nutrients. Additionally, green manures help in mobilizing nutrients, enhancing growth promoting substances, suppress soil-borne pathogens and support crops to out-compete weed and prevent soil erosion.

(2) Biodiversity Conservation

Organic farming is now seen as a potential solution towards reducing the loss of biodiversity. As organic farm practices are largely intrinsic and enhance food resource, habitat heterogeneity (management of field margins and non-crop habitats), prey-predation relationships, and reduce toxic influences (prohibited use of chemical pesticides/ inorganic fertilizers), these are expected to support species vulnerable to otherwise conventional farm practices. Although a number of caveats apply for making a generalization, promotion of biodiversity conservation has been now well accepted as an important benefit of organic management. So far, the available evidence clearly indicates that organic farming plays a significant role in preserving and conserving the biodiversity resources.

- There is clear evidence of elevated bacterial and fungal abundance and activity under the organic system. Pandey and Pandey (2009a) have reported 17-26% increase in microbial biomass and activity in organically managed experimental plots. Bacterial feeding nematodes were found to be more abundant under organic management.
- Higher earthworm abundance has been reported in organic than in conventional fields. Organic management supports more active earthworm population, number of species and more juvenile earthworms regardless of crop type.
- Organic management supports a significantly

higher number of butterflies, spiders and beetles. Higher abundance and species richness of carabids and epigeal spiders have been reported in organic farms. Also, the organically managed fields support a number of species of non-coleopteran arthropods than the conventionally managed fields.

- Studies show that organic fields support a greater number of vertebrate species (mammals and birds). Studies conducted in other countries show that small mammals such as the wood mouse (*Apodenus sylvaticus*), common shrew (*Sorex araneus*) and bank vole (*Clethrionomys glareolus*) in organic farms did appear greater in number than the conventional fields. Many species of bats actively select organically managed habitats. High abundance and diversity of invertebrates and plants in organic fields support a variety of avian community.
- Management of field margins and non-crop habitats support higher abundance and richness of weeds and non-crop flora in organically managed fields. In particular, these differences have been shown to be greater for broad-leaved weed species belonging to Fabaceae, Brassicaceae and Polygonaceae. Hedges of organic fields display significantly higher species diversity than those supported on conventional farms.
- Organic farming, by definition, reduces pollution of water bodies by pesticides and inorganic fertilizers. The overall effect is a significant increase in richness and abundance of aquatic species in waterways located downstream organic fields.

Ample evidence is now available suggesting that organic farming can play a significant role in increasing/conserving biodiversity across the landscape. Although, benefits of organic farming to biodiversity vary, the extension of organic farms can contribute to the restoration of biodiversity resources in the agricultural landscape. Because this effect varies according to the factors such as location, crop-type, species, climate and also with farm practices, there is a pressing need for more long-term, system-level studies on biodiversity responses to organic management on landscape-scale.

(3) Carbon sequestration

Knowledge of C-storage relative to flux in agro-ecosystems is essential for predictive geosphere-biosphere modeling and for reducing the excess of atmospheric CO_2 levels through C-sequestration. As per the IPCC (2007), the soil carbon sequestration is cost effective and may contribute to ~89% of total C mitigation. Our country with almost all major climatic zones and range of land usage has vast opportunities for soil C-sequestration. Conversion to agricultural land use may lead to loss of SOC pool by 60% in temperate soils and over 75% in the soils of tropics (Lal, 2010). Compared to the carbon stored in a forest, the SOC in agricultural soils can effectively benefit food production and improve agricultural sustainability. An increase of 1 ton of

soil C pool of degraded cropland may increase crop yield by about 10 to 20 kg/ha of maize, 20 to 40 kg/ha of wheat, and 0.5 to 1 kg/ha of cowpeas indicating a strong link between C-sequestration and crop production (Lal, 2010).

Further, a recent study in Punjab indicated that organic amendments significantly reduce methane emission from rice field (Khosa *et al.,* 2010). Considering the vast potential of C-sequestration and GHG emission mitigation, the government needs to encourage farmers towards the adoption of RMPs for climate change mitigation and sustained food security.

(4) Reduced energy dependence

The conventional farm systems require more overall energy inputs than do the organically managed systems. Fossil fuel energy input is required in farm machinery, transport, production of synthetic fertilizer and pesticides, etc. Synthetic fertilizers, used in conventional systems, are produced employing fossil fuel energy whereas cattle manure, legumes, etc., with very low energy needs, are used in organic practices. In a study, Pimentel *et al.* (2005) have quantified that fossil fuel inputs in organic production of corn were ~30% lower than the conventionally produced counterparts. This marks the additional benefit in terms of comparatively lesser release of CO_2 to the atmosphere and therefore helps mitigate climate change. Reduced energy use in organic farms thus not only reduce economic load but also share to solve environmental problems such as climate change.

B. Economic sustainability

The conventional mode of agriculture, which works on the principle of diminishing return, may cause long-term economic risks influencing the overall balance of trade compared to its sustainable counterpart. In a sustainability perspective of organic farming, the following issues need concern:

1. *Export orientation:* The Indian organic produce market is export-oriented. It involves hidden costs such as transport and has risks to local food security. Policies considering local demands/ markets are needed for a rational balance of trade.

2. *Market risk:* Concentrating on specific commodities is vulnerable to market risks. A disproportional sweep in the international market may lead Indian farmers to risk. As a WTO signatory, the government is bound to open its economy to the global market and thus, unable to protect the farmer's interest in this respect.

3. *Employment:* The organic farming system, being labor-intensive can help overcome rural employment.

4. *Cost-benefit analysis:* Agriculture forms the base of economic policies and poverty alleviation in many countries including India. Model estimates show that organic farming can reduce pesticide use by 50% to 65% without compromising crop yields and quality together with 50% less expenditure on the fertilizer and energy use (Pimentel *et al.,* 2005).

A study, based on 120 farmers of Shimoga and Bhadravati Talukas of Karnataka, conducted the cost-benefit analysis of organic rice production (Suresh and Kunnal, 2004). They show that although the average cost of organic cultivation per acre was lower only marginally, the net benefit increased by over 40% indicating that organic farming is beneficial in an economic perspective also. Another study by the Central Institute for Cotton Research, Nagpur indicated that the cost of organic cultivation was about 21% lower than that those under conventional farming.

Constraints in Organic Farming

A. Environmental constraints

(1) Water quality

Accumulation of heavy metals in agricultural crops depends on soil processes and properties, plant and soil physical factors, mobilization of metals, concentrations of heavy metals in soil and in irrigation water (Pandey *et al.*, 2012). Wastewater irrigation has become a very common practice in many countries including India. Some countries recommend wastewater irrigation for grain crops and those grown for fodder and slaughter stocks. Wastewater is increasingly being used for irrigation in urban and peri-urban areas of the developing countries due to easy availability and scarcity of unpolluted water. Irrigation of crops with wastewater may cause heavy metal accumulation and degrade soil quality (Pandey *et al.,* 2012). The overall effect is reduced crop growth and risks to human health. For the success

of organic farming, efforts should be made to ensure the availability of contamination-free fresh waters. In this context, a massive drive to manage surface and ground waters for irrigation and other usage is essential.

(2) Atmospheric deposition

High atmospheric deposition and accumulation of heavy metals in crops and vegetables have also been reported in India (Pandey and Pandey, 2009b). It can affect human health through dietary intake and food chain associated routes. Atmospheric deposition of heavy metals has been shown to lead multifold accumulation in eggplant, tomato, spinach, carrot, amaranthus and radish and cause damage to microbial activity in organically amended soil (Pandey and Pandey, 2009b). Thus, the atmospheric deposition of heavy metals may constrain compromising organic farming with respect to its ability to stabilize soil fertility and provide toxin-free produce.

B. Resource need

Livestock resources play important role in strengthening agricultural practices for large masses in India. With the advent of technology, the livestock population in our country has declined sharply. Between 1997 and 2003, cattle population in India declined by 10.23% and those of mules, camel and donkey the declines were 20.36, 30.70% and 26.30 respectively. Improved pasture and rangelands are essential for supporting livestock and restoring C-pool, nutrient cycling and soil quality. The natural pasture cover in India is rapidly declining and the problem is more acute in dry regions.

A large part of the rural population in our country is poor and depends on animal manure for domestic fuel. This further constrains the availability of animal manure for agricultural use. In a rural household in our country, about 1500-2000 kg of cattle manure is used for domestic fuel annually. To remove this 'competitive' constraint, useful options and appropriate farm-scale management strategies are required. Lack of sufficient stock of vermicompost and biofertilizers in the local market further constrain the organic producers. Further, constraints associated with the availability of appropriate amount of biopesticides may also lead organic producers in India to risk. Additionally, most of the crop residues in our country are removed from the fields for the purpose of fodder and fuel. This has led the use of mulch farming technique towards failure. In addition, there must be some appropriate microbe-based technology for optimizing the use of natural resources to sustain agricultural production in India (Pandey and Pandey, 2017; Anandaraj, 2019). More recent studies show that the use of agricultural biostimulant may be an effective tool in making agricultural production more sustainable and resilient.

C. Certification

Problems associated with certification, for instance, a time lag of three-years (conversion stage), often constrain small landholders from adopting organic farming. The certification is essential to authenticate organic produce and to validate the price margin in the market. The Director General of Foreign Trade (India) permits the export of organic produce if these are produced and processed under a valid certification. Lack of knowledge and access to certification discourage the small farm holders in India. To overcome these issues, training and institutional demonstration with fiscal incentives is being provided to encourage small farm holders.

D. Social acceptance

The increasing demand for organic produce is viewed as a new opportunity to aspire the economic boom with lucrative export markets. However, the majority of small farm holders depend on government incentives and are striving for a profit margin in the indigenous market. Therefore, small farm holders in our country are apprehensive towards adopting organic farming. Major issues that need to be resolved to encourage acceptance in small farm holdings include access to certification, lack of local market, cost-benefit anomalies, lack of appropriate knowledge to RMPs and non-availability of organic supplements.

Conclusion:

Indian agriculture has evolved as an ecologically sustainable approach based on natural inputs to obtain desired crop yield. The modern innovation and technology-based agriculture although increased the yield by many folds have caused a large-scale environmental degradation including the loss of biodiversity. With a large geographical area and diversity of eco-region, our country has a considerable potential to capitalize on organic farming. However, small farm holders in India are constrained by issues such as resource availability, certification, lack of local market and other factors. Therefore, an integrated effort is needed by the government and non-government organizations to remove constraints encouraging small farm holders to adopt organic farming as a solution to meet food demand while conserving the soil, water, energy and biological resources.

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