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Organic farming for sustainable vegetable production and livelihood enhancement

Vegetables being highly nutritious and easily digestible, hold major position in eradicating hunger and malnutrition and offer vast potential for ensuring food and nutritional security for millions of people of our country. Moreover, most of the vegetables are capable of giving very high yields and economic returns to the growers in a short period of time, besides generating on-farm and off-farm employment. As a result, in recent years, major emphasis is given for commercial exploitation of vegetable crops. However, under conventional production system, a large quantity of pesticide is being used by vegetable growers at frequent intervals to manage insect-pests and diseases in vegetable crops. Herbicides and chemical fertilizers which are used for conventional vegetable production are also the source of ground water pollution, environmental deterioration and contamination of food, as they enter the food chain. There are innumerable health hazards posed by these agro-chemical contaminated vegetables due to the presence of higher pesticide residues, heavy metals, etc. Hence, there is need to produce food devoid of contaminants. Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment and restricts the use of synthetic inputs.

WITH the increasing awareness about the safety and quality of foods, long term sustainability of the system and accumulating evidences of being equally productive, the organic farming has emerged as an alternative system of farming which not only addresses the quality and sustainability concerns, but also ensures a profitable livelihood option. As a result, organic farming of vegetables is gaining momentum across the world and emerging fast as an attractive source of rural income generation. India with its varied climate and variety of soils has an enormous potential for organic production of vegetables and revenue generation through export. The Indian organic food market stood at a value of USD 1238 million in 2022 and is likely to grow at a CAGR of about 22% in the forecast period of 2022 and 2028 to reach a value of about USD 4082 million by 2028. This implies that organic farming has emerged as an avenue of remunerating farm enterprise.

Benefits of organic farming

Produce quality: Organic produce contains more vitamins, minerals, enzymes, trace elements and even cancer fighting antioxidants than conventionally grown food. The quality, taste, flavour and storage attributes improve in organically produced vegetables mainly through increased dry matter, vitamin C and content of protein. Studies at IIVR, Varanasi, revealed that the vitamin C content in organically grown spinach, fenugreek leaf, cabbage and pea increased by 51.12, 25.76, 41.31, and 18.68%, respectively and the protein content in cowpea improved by 30% while lycopene content in tomato improved by 39%. Similarly, the total phenolic compounds and peroxidase activity also improved by 44 and 38%, respectively in organically produced cabbage. Organic farming also improved the physical attributes of vegetables. The organically produced cowpea, okra, cabbage, and tomato had better colour, lusture and texture. Organically grown okra and carrots were found to possess better quality attributes like taste, flavour and sugar content than those grown conventionally. Excessive nitrate intake is a serious threat to human health. Studies have confirmed that organically produced vegetables like potato, carrot, cabbage, beetroot, celery, leak, parsley and lettuce contain lesser levels of nitrates and higher levels of vitamin C content when compared to conventionally grown vegetable crops. Similarly, organically grown vegetables accumulate higher content of total sugars, minerals like phosphorous and magnesium, and phenolic compounds in vegetables like carrot, potato, spinach, brinjal, lettuce and cabbage. Organically grown vegetables like sweet pepper and brinjal exhibited higher levels of phenolic compounds, peroxidase and capsidol activity offering resistance to diseases. It has been observed that the average levels of minerals are much higher in the organically grown food than in the conventionally grown crops. Calcium is 63% higher, iron 73%, magnesium 118%, molybdenum 178%, phosphorus 91%, potassium 125% and zinc 60%. Further, it has been demonstrated that organically produced foods have lower levels of pesticides and medicinal and hormonal residues.

Soil health: Organic carbon built up was noticed in organically fertilized soils in vegetable crops at IIVR, Varanasi. Organic carbon is a good indicator of soil quality as it improves soil physical and biological properties and acts as the reservoir for nutrients. The carbon sequestration was 301.1 kg/ha/year under organic farming, while it was only 42.6 kg/ha/year under conventional system in cabbage. The loss of nutrient in organic manure is less due to its slow release. Higher P use efficiency was noted in organic soils due to the slow rate of release and fixation of phosphate ion in organic soils. The bulk density is less in organic field soil, which is a sign of better soil aggregation and soil physical condition. Besides, the increased organic matter content, which supports the soil micro, meso- and macro-fauna, makes the soil a living body and has higher microbial activity, which helps in nutrient transformation and increased availability of these nutrients to the plants. Organic matter improves soil structure and increases water-holding capacity. A steady increase in positive balance of Zn, Cu, Fe and Mn was recorded in organic plots as compared to conventional system. It is well documented that there is a significant positive co-relation between organic matter and micronutrient availability.

Profitability opportunities: The organic vegetables have high demand and it gets high premium price over conventionally grown vegetables. Organic vegetables fetch a premium price of 10 to 50% over conventional products. The cost of organic vegetable production is usually lower than that of conventional farming due to use of on-farm inputs. Studies have shown that common combination of lower input costs and favourable price premiums can offset reduced yield and make organic farming equally and often more profitable than conventional farms. Besides, use of botanical and bio-pesticides for insect-pest and disease management resulted in considerable reduction in variable cost. Studies on cotton also indicated that in organic cultivation over a period of six years, there is a reduction in cost of cultivation and increased gross and net return compared to conventional cotton cultivation. Thus, combination of low cost inputs and greater yield with premium price makes organic vegetable production equally/more profitable than conventional system. In India where 85% farmers are either small or marginal, any reduction/saving in cost of cultivation will go a long way in ensuring the sustainability of the system.

Climate change mitigation: Vegetables are generally sensitive to environmental extremes. The tropical vegetable production environment is a mixture of conditions that varies with season and region. Organic farms have greater diversity due to mandatory crop rotations and preference for crop varieties with high tolerance to complex abiotic and biotic factors. Through intercropping and other practices, organic farms establish systems of functional biodiversity that stabilize the agro-ecosystem. Resilience to climate disasters is closely linked to farm biodiversity; practices that enhance biodiversity allow farms to mimic natural ecological processes, enabling them to better respond to change and reduce risk. By increasing resilience within the agro-ecosystem, organic agriculture increases its ability to continue functioning when faced with unexpected events such as climate change. Thus, organic agriculture suffers less damage compared to conventional farmers planting monocultures. Organic farming practices preserve soil fertility, maintain or increase organic matter and enhance water-holding capacity of soil, which can reduce the negative effects of drought while increasing productivity in organic farming, helping farmers withstand drought. Practices such as crop residue retention, mulching and agro-forestry, conserve soil moisture and protect crops against microclimate extremes. Organic farming systems contribute to reduced consumption of fossil fuel energy, reduced carbon dioxide and nitrous dioxide emissions, reduced soil erosion and increased carbon stocks. Greenhouse warming potential in organic systems is 29 to 37% lower because of omission of synthetic fertilizers and pesticides. Carbon sequestration efficiency of organic systems is almost double as compared to conventional soils. Thus, organic farming can potentially contribute to mitigate threats from climate change on vegetable production.

Vegetable productivity under organic farming

It is noticed that during the conversion period, the crop yield is low compared to the conventional (using fertilizer and pesticides) and integrated crop management. However, the yields under organic farming system start rising from third year onwards and equals to that of the conventional system by the sixth year. Due to 10-50% more premium prices under organic farming, the net income increases progressively from fourth year onwards. Results obtained from 1050 organic field demonstration trials in different parts of the India showed an increase of 4% yield in plantation crops, 7% in fruit crops, 10% in millet and vegetable, 11% in fibre, condiments and spice crops, 14% in oilseeds and flowers and 15% in tobacco. After practicing 5-6 years of organic farming, the soil fertility sufficiently restored, the yield realized in organic farming of vegetable is either comparable or more than that realized in conventional farming. The studies at IIVR revealed that for tomato and cabbage grown during winter season and okra and cowpea grown during summer

season, the comparable yield under organic cultivation to conventional system were achieved during sixth year. However, in rainy season, for cowpea and pea, the comparable yield was recorded only in fourth year of consecutive organic farming.

Scope of organic farming in India

In India, National Programme for Organic Production (NPOP) was designed to establish national standards for organic products. The Agricultural Processed Food Products Export Development Authority (APEDA), Ministry of Commerce and Industries is implementing the NPOP Programmee. The NPOP has basic production standards applicable under Indian conditions and specified guidelines on cultivation of crops organically to be acceptable as organic, which could then be sold under the logo 'India Organic'. Export preference of organic vegetables offers a great scope to a country like India, which has inculcated the skill of growing organically since time immemorial. Organic farming is estimated to be growing at a rate of 30% a year worldwide in response to the market needs. This growth rate is highest in Japan, USA, Australia and EU. NPOP has been acclaimed by European Union, Sweden, Switzerland and USDA. Hence, any organic product certified by NPOP can be exported to Europe, Switzerland, Sweden and USA.

For promotion of organic farming, identification of potential areas and crop is crucial. To begin with, the practice of organic farming should be for low volume, high value crops like fruits and vegetables, where instead of quantity, quality is more important. Further, vegetables crops such as leafy and root vegetables where use of higher doses of chemical fertilizers, especially, N may lead to higher NO_3 content and imbalanced nutrition of crops, and plantation crops like tea, coffee, cashew nut, etc. where the nutrient removal is less and recycling through leaf fall is high are apt for organic farming. Horticultural crops having high export potential in international markets like spices, and local varieties of different crops having high quality and export potentials are suitable for cultivation under organic management. Soils having high fixation capacity of the nutrients like the calcareous, acidic and alkali soils, provide an opportunity for organic farming. Vegetables crops having great market potential find prominent place in the Government strategy to promote organic farming in the country. The rainfed and hilly areas of India provide considerable opportunity for organic farming due to least utilization of chemical inputs. It is estimated that 18 million ha of such land is available in the North-East region, which can be exploited for organic production.

Status of organic farming in India

As per the available statistics, India ranks 5th in terms of world's organic agricultural land and 1st in terms of total number of producers. Further, India is ranked among the top three countries, wherein the highest increase in land acreage (i.e. 359000 ha or +16% increase) under organic farming was noticed. In terms of number of affiliates of IFOAM – Organics International, India secured the 4th position (Source: FIBL and IFOAM Year Book, 2022). In India, total area under organic production is 9.12 million ha (2001-21). This includes 4.73 m ha cultivable area and 4.39 m ha for wild harvest collection. Among all the states, Madhya Pradesh has covered largest area under organic certification, followed by Maharashtra, Gujarat, Rajasthan and Odisha. The total production is 3.44 million metric tonnes (2021-22) of certified organic products. Among different states, Madhya Pradesh is the largest producer, followed by Maharashtra, Rajasthan, Karnataka and Odisha. The total volume of export of organic produce during 2021-22 was 460320.40 metric tonnes from which realization was about ` 5246.32 crores. Organic products were exported to USA, European Union, Canada, Great Britain, Switzerland, Turkey, Australia, Ecuador, Korea Republic, Vietnam, Japan, etc.

Steps in commercial organic farming

Organic conversion: It is the interim period required for establishment of an organic management system and building of soil fertility. The duration of the conversion period depends upon the past use of the land and also the ecological situation. In general, 2-3 years conversion period is required.

Organic management: The organic management starts from the conversion period and it includes number of activities.

Habitat management: It constitutes plantation on the farm to encourage creation of biodiversity on the farm and construction of structure for on-farm production of manures/compost/ plant protection materials.

Choice of crops: All seeds and planting materials should be certified organic. Species and varieties should be adapted to the soil and climatic conditions; these should be resistant to pests and diseases. Use of genetically modified seeds, pollen, transgenic plants or planting materials are not allowed.

Soil fertility management: In organic farming, soil fertility management depends on biologically derived nutrients through recycling of on-farm inputs, crop rotation, crop residues, etc. Use of organic manures such as composts, vermicompost, FYM, oil cakes and bio fertilizers (*Rhizobium*, *Azotobacter, Azospirillum, Azolla,* AMF, PSB, etc.) as well as green manuring either through *in situ* growing of leguminous crops (*Dhaincha*, sun hemp and cowpea) or through *ex situ* addition of green lopping from *Pongamia* or *Gliricidia* trees. Efforts are made to minimize losses of nutrients and maximize the input use efficiency and minimize the accumulation

of toxic substances in the soil. Manures containing human excreta are prohibited for use on vegetation for human consumption. All synthetic fertilizers are prohibited. Soil and water conservation practices are integral part of all activities in soil management on organic farms.

Weed management: Weed management is one of the most challenging aspects of organic vegetable production, even with rigorous crop rotation. Failure to manage weeds effectively results in reduced crop yield. The critical weed-free period for most of the vegetables is about 4-6 weeks after transplanting (or longer if the crop is direct-seeded). Weed management can be accomplished through mechanical methods, cultural methods, growing cover crops, suppression of weeds through crop competition and mulching.

Insect–pest and disease management: Organic insect/disease management is based on a combination of preventive techniques, cultural practices, natural remedies, botanicals and limited use of permitted chemicals. Use of resistant varieties is the most important. Prevention and sanitation procedures are also important. Products of traditional nature, preferably prepared at the farm from local plants, animals and microorganisms should be used. Both physical and thermic methods are permitted. Thermic sterilization of soil is allowed to combat pests and diseases. All the synthetic pesticides are strictly prohibited. Appropriate integrated pest management strategies consisting of cultural practices, crop rotation, intercropping, trap crops, pheromone traps, biological control, etc. have to be followed for effective management of pests and diseases.

Organic certification

Organic certification system is a quality assurance initiative, intended to assure quality, prevent fraud and promote commerce, based on set of standards and ethics. To ensure the implementation of NPOP, the National Accreditation Policy and Programme (NAPP) was formulated, with accreditation regulations. Accreditation of Certification and Inspection Agencies is being granted by a common National Accreditation Body. These make it mandatory that all certification bodies, engaged in inspection and certification of organic crops and products, should be accredited by National Accreditation Body. APEDA is the nodal agency for accreditation of Inspection and Certification Agencies in the country. The farmers growing crops as per NPOP Standards are eligible to get the certificate and the organic label. The farmers can sell the organic produce in the local as well as International markets based on 'India Organic' logo. In order to ensure certification by any agency, the producer has to satisfy the following criteria:

- Adherence of the organic standards as prescribed by the certification authority.
- The production practices and farm facilities have to comply with the norms and standards.
- Detailed documentation of the entire farming procedures adopted and farm facilities is required.
- Periodical inspection by the authorities concerned

For internal market, Participatory Guarantee System (PGS) was introduced, which is process of certifying organic products that ensures agriculture production process is in accordance with the standards laid down for organic products under NPOP and that desired quality has been maintained. Based on internal quality system, the PGS system of certification works. This PGS is applicable to producer groups, farmer's cooperatives, contract production and small-scale processing units. The producers in the group must apply similar production systems and the farms should be in geographical proximity.

CONCLUSION

Environmental problems arising due to non-judicious use of chemical fertilizers, pesticides and machinery can cause land degradation and irreversible ecosystem damage. Organic agriculture system has strong potential for building resilient food system in the face of uncertainties through farm diversification and building soil fertility with organic residues. There is immense scope for organic production of vegetable crops in India since the agricultural sector has enormous organic resources like crop residues, livestock and other bio-products from agro industries. Certified organic vegetable products offer high-income options for farmers and therefore can serve as promoters for climate friendly farming practice worldwide.

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Organic fertigation system

An organic fertigation unit was developed for use of cowdung and vermicompost filtrates as a nutrient source for crops. A power-operated agitator was also fabricated for the organic fertigation unit for large-scale vegetable cultivation. The proportion of manure and water, duration of agitation, and settling time of manure solution were optimized to improve the nutrient content of supernatant and filtrate using the power-operated agitator. Vermicompost filtrate prepared by mixing vermicompost and water in a ratio of 1:5 followed by agitation for 10 min and settling for 6 hr showed increased nutrient content (K, P, Ca and Mg) in the filtrate. It was recommended that organic manure filtrate along with a 50% recommended dose of fertilizer should be applied to get a higher yield of okra and improve the nutrient and microbial status of the soil.

Source: ICAR Annual Report 2022-23