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ORGANIC FARMING IN INDIAN CONTEXT: A PERSPECTIVE

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ABSTRACT

Green revolution technologies played a great role in alleviating hunger but have also resulted in some adverse effects on our natural resources. Due to these adverse effects, stress is being laid on alternate forms of agriculture that are more sustainable. Organic farming, a holistic way of farming, is one of these alternate forms that are aimed at sustainable agricultural production. It relies on crop rotations, green manures, organic manures, biofertilizers, composts and biological pest management for crop production excluding or strictly limiting the use of synthetic fertilizers, chemical pesticides, plant growth regulators and livestock feed additives. No doubt, the advantages of organic farming outweigh its disadvantages but in practical it has several constraints viz. threat to national food security, limited availability of organic manures, profitability to farmers and affordability of organic produce by consumers. Thus, a complete shift to organic farming is neither desirable nor possible in high input use areas which are the major contributors of food grains to central pool. Systematic phasing out of agrochemicals and synthetic fertilizers in these areas may be a step in right direction. 'Towards organic' (integrated crop management) approach for input-intensive areas (food hubs) and 'certified organic' approach by integrating tradition, innovation and science in the de-facto organic areas (hill and rainfed/dryland regions) will be better option for national food security, higher household income and climate resilience.

Key words: Constraints, Organic farming, Pest management, Productivity, Prospects, Quality, Soil health

The growing awareness about human health and environmental issues relating to agrochemicals' use in agriculture has led to interest in alternate forms of sustainable agriculture. Organic farming is one of these alternate forms that are aimed at sustainable agricultural production along with conservation of natural resources. Its global importance owes to adverse effects of modern agricultural practices on environment and soil health and appearance of pesticide residues in human food chain. It is a holistic way of farming in which quality agricultural production is achieved with an aim to conserve, rather improve, natural resources where as conventional or modern farming, on the other hand, is more akin to the factory farming which gives emphasis on input based maximization of crop productivity.

Organic farming relies on crop rotations, green manures, organic manures, biofertilizers, composts and biological pest management for crop production excluding or strictly limiting the use of synthetic fertilizers, chemical pesticides, plant growth regulators and livestock feed additives. However, it does not mean a reversal to the farming methods of 18th century; rather it combines the traditional and modern approaches like improved seeds, biopesticides, new machinery and equipments, biofertilizers etc. But, before going into the details of organic farming, we need to have a look at the genesis of modern agriculture.

Genesis of modern agriculture

Agriculture was organic in nature before the 19th century though without any such nomenclature and was practiced using organic manures and human and animal power of horses in the US and oxen in Asia (White, 1970) and this was the conventional agriculture of that times. The agricultural revolution began in England in the early 19th century with the invention of horse-drawn hoe and a seed-drill by Jethro Tull followed by the classical monograph on agricultural chemistry by Liebig in 1840. The establishment of Rothamstad Experimental Station in 1843, was profoundly influenced by the Liebig tradition (Howard, 1940). This was followed by manufacturing of superphosphate fertilizer in England in mid 19th century and tractor with an internal combustion engine in the US in 1910 (Rasmussen, 1973). Fritz Haber's process of ammonia synthesis led to the manufacture of nitrogenous fertilizers in Europe and the US (Collings, 1955). The discovery of insecticidal properties of DDT (Dichloro, diphenyl trichloro acetic acid) by P. Muller in Switzerland in 1939 was followed by the discovery of BHC (Benzene hexachloride) in France and UK (Brown, 1951). Nitrophenols, the first group of selective herbicides, developed in 1933 were followed by the development of 2, 4-D (2, 4-dichloro phenoxy acetic acid) and MCPA (2-methyl, 4- chloro phenoxy acetic acid) herbicides in 1940s. Thus, by the mid 20th century, the most of the components of modern agriculture, i.e. farm machinery, chemical fertilizers and agrochemicals were in vogue on agricultural farms in the developed world.

In India, the shift to modern agriculture dates back to the establishment of Department of Agriculture in 1881 followed by Imperial Agricultural Research Institute (IARI) at Pusa, Bihar and Regional Research Stations at Coimbatore, Pune

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and Phalmpur (Howard, 1926). The State Agricultural Universities were established in the 1960s on the model of 'Land Grant Colleges' of America and were primarily based on the American model rather than the Indian model of agriculture (Veeresh, 2006). Organic farming systems are very much native to Indian Agriculture. Traditionally, precisely before the dawn of green revolution, crops and livestock have been reared together in all the farm households. And, as of now also, in more than 85% of the farm-households field crops + livestock farming system is prevailing. Nevertheless, during pre-green revolution period (up to 1960s) our national agricultural growth rate was not able to keep pace with population growth rate and virtually 'ship to mouth' situation prevailed. This was the major driving force for introduction and large-scale popularization of high yielding varieties (HYVs) of crops, which were highly responsive to the chemical fertilizers and water use. As a result, the total food grain production increased phenomenally from mere 50.82 million ton in 1950-51 to 264.0 million ton in 2013-14, a fivefold increase. This increase can primarily be attributed to large-scale adoption of HYVs combined with other green revolution technologies (GRTs) in cereal crops, expansion of gross irrigated area (22.56 million ha in 1950-51 to 89.36 million ha in 2010-11) and increase in fertilizer use (0.07 million ton in 1950-51 to 25.54 million ton in 2012-13). All of them put together have led to substantial increase in the productivity of crops, especially food grains (from 522 kg/ha in 1950-51 to 2125 kg/ha in 2012-13), transforming India from a food importer to net food exporter (presently contribution of agriculture in total export value is 14.1%).

The chemical fertilizers replaced organic manures very fast because of their easy availability, ease in handling and storage and quick response of crops to their application. The adoption of these modern components of agriculture resulted in an unprecedented increase in agricultural production and a new term 'Green Revolution' was coined to describe this success in agricultural production. Though, green revolution technologies (GRTs) played a great role in alleviating hunger from the world and have been able to keep the 'Malthus predictions' at bay but also resulted in some adverse effects on environment and appearance of pesticide residues in agricultural produce (Kalra and Chawla, 1980; Chahal *et al.,* 1999; Singh, 2002).

Resurgence of organic farming

The word 'organic' in organic farming is a process claim and not a product claim as chemically, every food is organic but here it is the production process which makes the food organic. Thus, it is method of production, processing, storage and transportation that makes a product organic.

Organic farming is not limited to just abandoning the use of agro-chemicals in agriculture but is a system of creating a favourable agro-ecosystem on an agricultural farm. India's National Programme for Organic Production (NPOP) defines organic farming as, 'A system of farm design and management to create an ecosystem, which can achieve sustainable productivity without the use of artificial external inputs such as chemical fertilizers and pesticides'. However,

International Federation of Organic Agriculture Movements (IFOAM) defines organic farming as, 'A production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic farming combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved'.

Organic farming is thought to be originated in Asia where agriculture was not just a profession but a way of life. The first scientific approach to organic farming can be quoted back to the *Vedas* of the 'Later Vedic Period i.e. 1000 BC - 600 BC' (Randhawa, 1986 and Pereira, 1993). The essence of farming during that period was to live in partnership with, rather than exploit, nature. The farmers have nurtured and groomed this art over the centuries. However, Albert Howard, a British botanist, is often referred to as the father of modern organic farming. He worked in India from 1905 to 1924 and regarded traditional Indian farming practices superior to the conventional agricultural practices. He documented his research and further developments of these practices in his book, 'An Agricultural Testament'. Lady Eve Balfour in 1939 launched the Haughley Experiments on farmland in England to compare organic and conventional farming and based on her experiences published a book, 'Living Soil'. Rudolf Steiner in 1940 in Germany developed a system of biodynamic agriculture and introduced trademark 'Demeter' for the food produced on biodynamic farms. Peter Rush and Hon's Muller in Switzerland developed and promoted the concept of 'Biological Agriculture'. Masanabu Fukuoka, a microbiologist in Japan, developed a radical-no-till organic system for growing grains, now known as 'Fukuoka Farming'.

However, the term 'organic' in relation to farming for the first time was used by Lord Northbourne (1940) in his book 'Look to the Land' in which he stated, "The farm itself should have a biological completeness; it must be a living entity, it must be a unit which has within itself a balanced organic life." His reference here was not just organic inputs but a concept of managing a farm as an integrated, whole system (Lotter, 2003). Rodale in 1950s popularized the term and methods of organic farming especially through promotion of organic gardening in US. In 1962, Rachel Carson, a prominent scientist and naturalist, published 'Silent Spring' describing the ill effects of pesticides, particularly DDT on the environment and launched a worldwide environmental movement. In 1970s, the global movements concerned with pollution and the environment degradation, started laying more emphasis on organic farming and their efforts culminated into establishment of International Federation of Organic Agriculture Movements (IFOAM) in 1972 in France. Then, in 1975, Fukuoka released a book 'One Straw Revolution' which had a wide ranging impact on the agricultural world. In India, the foundation of modern organic farming was laid by the establishment of National Programme for Organic Production (NPOP) in 2001 followed by National Project on Organic Farming and Network Project on Organic Farming during 2004.

Soil health management

Despite the fact that plants take up nitrogen, phosphorus and potassium in inorganic form as NH_4^+ and/or NO^-_3, HPO_4^{-2} and/or $H_2PO^-_4$ and K^+, respectively; the restrictions on use of chemical fertilizers is owing to their high solubility leading to pollution of the ground waters, addition of heavy metals as impurities in these chemical fertilizers and environmental pollution in their use and manufacturing. The aim of nutrient management in organic systems is to optimize the use of on–farm resources and minimize losses (Kopke, 1995). The philosophy is to 'feed the soil and not the plants' and it means giving back to the nature what has been taken from it (Funtilana, 1990). Soil organic matter and humus are the important components of this philosophy and strongly influence soil bulk density, water holding capacity, infiltration rate, hydraulic conductivity and aggregate stability (Shepherd *et al.,* 2003). Organic manures are the major source of soil organic matter and their importance has been documented as early as 400 BC in *Krishi Parashara*. Kashyapa in *Kashyapiyakrishisukti* (800 AD) mentions the importance of goat dung, cow dung and vegetation (green manure) in raising the fertility of soil (Nene, 2010).

Plants use nutrients from organic sources through mineralization mediated by soil microorganisms. Waksman (1938) described the importance of microbes as 'without soil microbes, life on planet would come to standstill'. They play an important role in the mobilization of nutrients in the soil and make a significant contribution to maintain a healthy soil system and consequently healthy plants (Veeresh, 1990). Soil macrorganisms like earthworms, termites and other macro fauna also play an important role in decomposition of organic residues and their redistribution in soil profile. Aristotle recognized the importance of earthworms as 'intestine of earth' and Darwin as 'builders of civilization'; 'beneficent gardeners' and 'industrious ploughman'. Darwin said, "The plough is the most ancient and most important invention, but long before man existed, the land in fact was regularly ploughed and still continues to be ploughed by earthworms". A population of three ton of earthworms per hectare pass soil equivalent of 10 cm soil layer through their system in one year (Edward and Lofty, 1972). Termites and dung beetles in tropics are more or less equivalent to the earthworms of temperate regions in turning over the soil. Dung beetles play an important role in decomposition of animal dung and incorporate about 40 to 50 thousand ton of dung into the soil everyday in India (Hingston, 1923).

Leguminous green manure crop fixes the atmospheric nitrogen in the soil in the available form, improves the soil health, prevents nutrient leaching and consumes excess soil moisture (Virdi *et al.,* 2005). Parshurama in *Krishi Gita* had recommended green manuring for rice as early as 1500 AD (Nene, 2010). Green manuring saves 45-120 kg N/ha (Ladha *et al.*, 1988; Beri *et al.,* 1989). The introduction of legumes in crop rotation is not a new concept, the legumes like peas and chickpea were included in crop rotation involving cereals in the *Harappan* phase of Chacolithic period at *Nausharo* in late 3000 BC (Mehra, 2004). Yields of cereals following legumes in cereal-legume system are 30-35% higher than those in cereal-cereal in cropping sequence (Peoples and Craswell, 1992). Legumes play a unique role in organic farming systems because of their deep root system, ability of nitrogen fixation (Table 1) and suitability in varied rotations and inter cropping systems.

Table 1. Nitrogen fixation capability of different legumes

Crop	Nitrogen fixed (kg/ha)	
Greengram	50-56	60
Pigeon pea	4-200	100
Cowpea	9-125	80
Soybean	49-450	100
Chickpea	23-97	40
Lentil	35-147	40
Field pea	46-99	65

Source: Sekhon *et al*. (2002); Ahlawat and Gangaiah (2004)

The recycling of crop residues is an integral component of organic farming systems because of their role in improving soil health and restrictions on their burning on organic farms. Crop residues may be recycled through their soil incorporation, composting, vermicomposting and mulching. Crop residues have the potential to improve soil and water conservation, sustain soil productivity and enhance crop yields (Das *et al.*, 2003).

Biofertilizers are used to fix atmospheric nitrogen, solublize/mobilize soil phosphorus and can also be used to enhance the decomposition of crop residues. They have been reported to increase the crop yields by about 6-25% (Dahama, 1999). The biofertilizer inoculation increases the yield of chickpea by 13-76%, pigeon pea by 10-46%, green gram by 9-95%, mash by 32-54% and cowpea by 25-30% (Kler *et al.,* 2001). Azospirillum inoculations increase the grain productivity of cereals by 5-20%, millets by 30% and of fodder crops by over 50% (Dahama, 2003). Traditional knowledge and farmers' wisdom and perceptions should be used in nutrient management programmes (Acharya *et al.,* 2001). Organic preparation *panchgavya* (made of five cow products- dung, urine, milk, curd and *ghee*) has been reported to have growth promoting effect on plants (Sreenivasa *et al.,* 2009; Natarajan, 2003). Organic preparation, *jeevamrit* prepared from dung and urine of one Indian cow has been reported to be sufficient for organic cultivation of 12 ha (Palekar, 2009) but a study in Punjab (Anonymous, 2012) has reported its ineffectiveness as a nutrient source for field crops.

Pest management

Organic farming systems lay stress on creation of an ecosystem in which insect-pests, diseases and weeds can be managed for successful cultivation of crops. The balance between the harmful and beneficial organisms is achieved in favour of beneficial organisms. Biodiversity of fauna and flora at the farm ensures proper functioning of the ecological system and that is why different organic standards require a minimum percentage of farmland on an organic farm to be maintained as semi-natural habitats. Moreover, less incidence of insect-pests has been reported on crops raised with organic sources of nutrition (Surekha and Rao, 2000; Venkateswara Rao *et al.*, 1989).

Insect-pest management

Suitable crop rotations perform an important phyto-sanitary function in preventing the carryover of crop-specific pests from one crop to the other. Single crop farming does not take the advantage of the principles by which the nature works and man has destroyed the built-in checks and balances by which nature holds the species within bounds (Carson, 1962). Crop rotation with non-grass crops helps in reducing the borer population (Alvares, 1999). A typical rice field in the tropics supports about 800 species of friendly insects like spiders, wasps, ants and pathogens that if recognized and protected can control 95% of insect-pests (Alvares, 1999). Rice yields do not decrease with stem borer attack as the number and/or size of grains increase in the remaining stalks (Fukuoka, 1992). Brown plant hopper in rice can be controlled by lighting powerful crackers in infested spots (Alvares, 1999). Rice leaf folder can be managed by running a rope in rice fields (PAU, 2017). Lesser number of eggs, larvae and adults of American bollworm have been reported in cotton under organic farming than under the conventional method (Sharma, 2003).

Certain plants produce secondary metabolites like terpenoids, alkaloids, flavonoids and phenolic compounds which have insecticidal properties and can be exploited as botanical pesticides. Neem seed kernel extract (NSKE) @ 5% is quite effective against *H. armigera* and seed treatment @ 10 ml/kg seed and drenching with 10% solution @ 4 litre/ha of Aonla (*Emblica officinalis*) is effective in controlling termite in chickpea (Gaur and Sharma, 2010). Neem pesticide reduces fruit borer (*Earias* spp) attack on okra (Ambedkar *et al.*, 2000), has antifeedant and insecticidal effects against *Achaea janata* on castor (Babu *et al.*, 1997), has low toxicity to spiders in rice (Baitha *et al.*, 2000a) and controls the leaf roller in rice (Baitha *et al.*, 2000b). Sucking pests can be repelled by spraying a preparation of 4 litres of cow urine and 10 g of asafoetida in 10 litre water (Alvares, 1999).

The use of biological methods for pest management is not a new concept as there are Biblical references to the use of the *Oecophylla* ant for controlling the date palm caterpillar. Biological control was discovered by trial and error and then practiced in agriculture long before the term itself came into use (Baker and Cook, 1974). Trichogramma, a parasitoid, application in sugarcane at 50,000 eggs/ha at 10 days interval from July to October results in significant reduction in damage by stalk borer (Singh *et al.,* 1997). Stem borer in rice can be managed by six releases of *T. chilonis* or *T. japonicum* (Jain and Bhargava, 2007). Bt formulations have been found effective against *H. armigera,* leaf webber (Gujar *et al.*, 2000) and other pests of crops. A predator *Cryptolemus montrouzieri* has proved effective in controlling mealy bug, a pest of citrus and coffee in south India (Kaul and Dhaliwal, 2000). Though, commercial biopesticides are available in the market but the majority of the organic farmers use on-farm preparations for pest management (Aulakh *et al.,* 2009).

Cultural practices like planting methods also affect incidence of insect-pests. Manipulation of planting or sowing times and crop geometries create an unfavourable environment for the potential insect-pests. Late sown maize is less damaged and winter maize escapes stem borer attack. Ridge sowing reduces the incidence of pod borer in Tur (Agrawal *et al.*, 2003) and cut worm in sunflower (Bakhetia *et al.*, 1995). Cotton when sown early experiences less bollworm attack. The detopping of cotton reduces incidence of *Heliothis*. Early sowing (end September-beginning of October) of potato and rapeseed (upto 3rd week of October) reduces infestation of aphid. Lopping of tall varieties of basmati rice, apart from preventing lodging, also decrease the stem borer incidence.

Conservation and promotion of natural enemies is done by providing artificial structures like nesting boxes for wasps and predatory birds; planting or retaining food or shelter plants on the boundary; placing bundles of rice straw for attracting spiders and other predators and by using trap crops. Sunflower as live bird perches has been reported to be effective in controlling pod borer of chickpea by Gopali *et al.* (2009).

Disease management

Design of proper crop rotations is an important preventive measure to check carryover of crop-specific diseases from one crop to the other. Suitable crop rotations and cropping systems like intercropping and mixed cropping help reducing the incidence of diseases. Barley + chickpea and wheat + chickpea intercropping systems reduce spread of rusts and gives significant control of *Ascochyta* blight. Organic crop management practices, that promote microbial population feeding on nematodes, cause a reduction in the relative abundance of plant parasitic nematodes (Surekha *et al.,* 2010). Green manuring with sunnhemp or sesbania reduces sheath blight (Alvares, 1999). Chickpea : mustard (5:1) and chickpea : barley (2:1) intercropping experiences less attack of blight (*Ascochyta rabiei*) (Gaur and Sharma, 2010). Cotton + moth mixture helps check the root rot of cotton.

Late sowing of chickpea in end November to December reduces root rot, wilt and blight diseases. Early planting of mustard helps in managing the white rust. The incidence of yellow vein mosaic disease in okra is less if sown during Feb-March. Deeper sowing in chickpea reduces the incidence of *Ascochyta* blight.

Trichoderma viride can be used for control of root and stem rots, wilts, blights and other fungal diseases (Vinale *et al.,* 2008). *Pseudomonas fluorescens* is effective against root and stem rots, damping off, blights, downy mildews and powdery mildews and other fungal diseases. Garlic extract @ 10% checks growth of *R. bataticola* and *Fusarium oxysporum* of chickpea (Gaur and Sharma, 2010). Downy mildew of bajra can be controlled with raw cow milk (Kumar and Mali, 2010). Application of cow urine is effective in controlling sclerotinia rot caused by *Sclerotinia sclerotiorum* of cucumber (Basak *et al.,* 2002). *T. viride* and *T. harzianum* control blast disease in rice; *Pseudomonas aeruginosa* and *Pseudomonas putida* reduce sheath blight infection (*Rhizoctonia solani*) in rice; arbuscular myorrhizal (AM) fungal minimizes sheath blight (ShB) disease incidence (Hazra *et al.,* 2015).

Intercropping of green gram, black gram and cowpea in sugarcane reduces the incidence of sugarcane early shoot borer (Venugopala Rao, 2010). Drip irrigation in sugarcane reduces the red rot in sugarcane (Rajeev *et al.,* 2003). In situ green manuring of dhaincha reduces red rot incidence in sugarcane (Sezhian, 1999). Cultural practices like planting methods also affect the incidence and spread of diseases. Ridge sowing helps to reduce late blight in potato and smut diseases in wheat (Sood, 1988; Hassabnis *et al.,* 1997) and flat sowing reduces leaf rust in wheat (Hassabnis *et al.,* 1997). Wider spacing in groundnut helps to control the *tikka* disease (Ghewande, 1982). Dusting of cow dung ash on plants to protect them from certain fungal diseases has been a very common practice in India.

Reduction in Gundhi bug population (*Leptocoryza varicornis*) by foliar application of vermiwash, neem oil, aqueous garlic and annona leaf extract has been reported by Mishra *et al.* (2015). Smearing of seeds followed by root dipping of seedlings with *T. harzianum* controls diseases in basmati rice (PAU, 2017). Loose smut (*Ustilago tritici*) of wheat can be controlled by soaking the seed in water from 8 am to 12 noon on any calm and sunny day during May-June followed by complete sun drying (PAU, 2016).

Weed management

Weed management in organic farming systems is aimed at minimizing the weed competition with the crop. It is achieved by integrating all the method of weed management excluding the herbicides. Selection of crop cultivars plays an important role in crop weed competition because of morphological features, canopy structures and relative growth rate. The traditional tall growing varieties perform better than modern dwarf varieties under unweeded situations (Reddy and Reddy, 1995) and this is the reason that most of organic growers grow traditional tall varieties in addition to their better *chapati* making quality. *Phalaris minor* can be managed by rotating wheat with other *rabi* crops such as berseem, potato, raya or gobhi sarson, winter maize, oats (fodder), sugarcane, etc. and also by early sowing of wheat in October. Narrow row spacing of 15 cm (Mahajan and Brar, 2001) and bed planting of wheat (Aggarwal and Goswami, 2003) also help in managing the weeds. One interculture with bed planter in bed planted wheat followed by manual hoeing is quite effective in managing the weeds (Singh *et al.,* 2002). In bed planted wheat the weeds can also be removed from fields near maturity of the crop and thus helps preventing the weed seed dispersal. Summer ploughings help controlling *Cyperus rotundus* by exposure of its tubers to sun (Tewari and Singh, 1991).

Mulching apart from increasing the economic yield of crops by providing congenial environment for their growth also provides a good control of weeds. Effective control of weeds with paddy husk or wheat straw mulch has been observed in turmeric (Mahey *et al.,* 1986; Dhaliwal, 1988; Randhawa, 1997). Intercropping of cowpea in maize and harvesting it at 40-45 days after sowing, apart from fodder, provides effective control of weeds (PAU, 2017).

Allelopathy, meaning mutual harm, is an interference mechanism in which a living or dead plant releases allelo-chemicals exerting an effect on associated plants which plays an important role in natural and managed ecosystems (Inderjit and Duke, 2003; Kong *et al.,* 2006). This mechanism can be exploited for weed management by using allelopathic crops or their residues. Allelopathy can be exploited as a tool to control weeds in field crops by using allelopathic water extracts (Iqbal, 1997; Cheema and Ahmad, 1992). Weed management by extracts of sorghum, sunflower and eucalyptus are frequently reported (Cheema *et al.,* 2003; Cheema *et al*., 1997; Khaliq *et al*., 1999). Allelo-chemicals present in certain plants like eucalyptus and sorghum interfere with photosynthesis and respiratory metabolism of weeds resulting in their reduced growth. Leather (1987) reported 13 genotypes of cultivated sunflower to be very allelophathic to several weeds. Harrison and Peterson (1994) reported inhibition of growth of yellow nut sedge (*Cyperus esculentus*) by sweet potato under field conditions. Release of phytotoxic ferulic acid from wheat crop residue suppresses *Ipomoea purpurea* and *Sida spinosa*. Allelochemical effect of rice stubbles and straw has been reported against *Phalaris minor* and other weeds. Lovett and Hoult (1995) described self defense in barley because of its allelopathic properties against weeds due to presence of gramine and hordenine.

Crop productivity

Crop productivity is an important factor influencing the food security of the nation as the land resources are declining year after year. Grain yields of paddy up to 2.95 t/ha (2605 lbs/acre) in the first crop (Kuruvai) and 2.81 t/ha (2484 lbs/acre) in the second crop (Thaladi) under traditional farming practices during 1925-26 have been recorded by Lalgudi Sivagnanam Co-operative Agricultural Society in the Madras Presidency [Royal Commission on Agriculture in India report volume III, 1927]. Similarly wheat yield of 2.41 t/ha has been reported from West Bengal during 1970-71 [Report of National Commission on Agriculture, 1976].

Though, there are reports of quite high yields of crops with traditional practices but lower crop yields under organic farming compared to conventional farming are quite common. The lower crop yields during the initial years of start of organic farming are primarily due to less supply of nutrients to crop plants due to slow release of nutrients from organic sources (Bhardwaj and Omanwar, 1994). About less than 30% of N and small fraction of P and K in organic manures are available to the immediate crop and the rest to subsequent crops (Sharma and Vyas, 2001). Only half of the nitrogen and one-fifth of phosphorus may be recovered from organic manures in first season of their application (Brady, 1996). The research experiences have shown that chemical farming gave higher yields of *kharif* (maize/soybean) as well as *rabi* crops (wheat/*gobhi sarson*) during first three years of study as compared to organic farming. In the fourth year, the *kharif* crops under organic farming showed an increasing trend in productivity than chemical farming, whereas *rabi* crops did not show any differences. Organic treatments followed a steady increase of 20 - 50% in crop yields at the end of the study compared to first year yields with the exception of potato where the tuber yields was not stable over the years (Kler *et al.,* 2002a,b; Kler and Walia, 2004). The highest total system productivity and net returns were observed with chemical fertilizers followed by integrated and organic sources (Urkurkar *et al.,* 2010). A gradual increase in grain yield of rice with the use of organics over a period of time was observed by Surekha (2007). Ramesh *et al.* (2008) reported a decrease of 5-15% in rice grain yield and 35-58% in wheat grain yields with FYM as source of nutrition. Higher yield reduction in wheat could be due to slow release of nutrients from FYM during cool winters. In sugarcane 10 t FYM/ha and 10 t vermicompost/ha were 75% and 100%, respectively as effective as application of 150 kg N, 60 kg P and 60 kg K/ha (Singh *et al.,* 2007). Yadav *et al.* (2002) reported lower yields of rice and wheat compared with conventional farming during first four years of study.

Higher maize, soybean and wheat yields were obtained under organic farming than chemical farming with green manuring and application of FYM 10 t/ha to maize and 5 t/ha to soybean in *kharif*, 15 t/ha to wheat in *rabi* and crop residue incorporation of all the crops (Walia, 2004). Walia and Kler (2009) reported at par rice and wheat grain yields with organic sources and chemical fertilizers.

Several studies (Bhattacharyya *et al*., 2003; Sarkar *et al*., 2003) have reported less average yield of cereal crops in organic farming than that with conventional production practices. Hazra *et al.* (2014) reported that flooded anaerobic rice cultivation is better than other field crops in organic farming. However, reduced rice grain yields have been reported with organic sources by Kumar *et al.* (1995). Scented rice grown with recommended inorganic fertilizers produced 20.1% higher grain yield when compared with the best organic source combination of green manuring @ 5 t/ha + FYM @ 10 t/ha (Kumari *et al.,* 2010). Rice productivity was at par under inorganic and organic fertilization where farmyard manure (FYM) application was 22.5 t/ha in rice and 20 t/ha or more in wheat. However, wheat productivity was

Table 2. Yield analysis of crops under organic and inorganic management at different locations in India

Crop	n[a]	Organic over inorganic		Crops	n[a]	Organic over inorganic	
		Mean	Range			Mean	Range
Positive organic							
Basmati rice	67	104	88-121	Okra	10	118	90-142
Rice	52	100	89-122	Chilli	12	109	107-112
Maize	37	110	62-137	Onion	13	107	87-127
Sorghum	17	114	89-132	Garlic	9	104	86-121
Greengram	12	107	96-122	Cauliflower	12	104	90-117
Chickpea	24	100	65-114	Cabbage	5	111	81-142
Soybean	54	104	96-123	Tomato	11	106	83-130
Groundnut	16	103	83-116	Ginger	12	120	108-129
Pea	21	125	94-162	Turmeric	18	146	93-242
Negative organic							
Wheat	55	93	78-113	Lentil	12	92	83-101
Mustard	32	93	67-137	Potato	32	95	48-162
Sunflower	8	99	94-103	Radish	9	75	43-108

n[a] = the number of yield entries

lower (30.5%) under organic than under inorganic fertilization even under the highest FYM dose (Kharub and Chander, 2008). Higher potato tuber productivity under recommended chemical fertilizers than organic source has been reported in Meghalaya by Baishya *et al.* (2010). Incorporation of crop residues + green manuring + phosphorus solubilizing microbes + poultry manure 5 t/ha + neem cake 0.2 t/ha, resulted in higher yield and net returns than inorganic management in rice-wheat system (Yadav *et al.,* 2009).

Rice and wheat yields under organic farming were 10% and 20% lower respectively than under conventional farming (Sharma, 2009). The crop yields under organic farming are influenced greatly by the cropping systems. Rice-wheat-mungbean system gave 16% higher yield of rice and 6% that of wheat than that under rice-wheat system (Davari and Sharma, 2009). The yield levels of most of the crops achieved by the organic growers are generally lower than the conventional system except the basmati rice which yields at par under both the systems (Aulakh *et al.,* 2009).

Analysis of yield recorded at various locations under organic over inorganic management indicates as many as 18 crops (Table 2) respond positively to yield under organic systems. The variation in yield is due to location specific package of practices adopted. However, it should also be noted that as many as 55 observations across the locations and over the years in wheat resulted in 7% reduction in yield. Any significant change in yield on the negative side especially in wheat is going to affect the food security in future. Hence, instead of blanket approach, niche crops, which are responding positively to organic and natural practices, should be promoted. Sustainability of yield is also very important to provide stable food for the ever growing population. Sustainable yield indices of basmati rice, rice, cotton, soybean, sunflower, groundnut, lentil, cabbage and French bean are higher under organic management compared to integrated and inorganic management systems. The lower sustainable yield indices in cereals under organic production were mainly due to unstable yield in wheat crop.

Produce quality

The answer to the question whether organic produce has better quality than the conventional produce can be both 'Yes' and 'No'; the yes when conventional produce is grown on soils deficient in essential minerals and this is likely to be expressed in the produce of that soils. If both the soils of conventional and organic farms are healthy soils then the chances of differences in quality are negligible. The information available on comparison of quality of organic foods and conventional foods is not consistent and expert opinions also differ. Usually, organic produce is considered to be healthier, safer and tastier than the conventional (chemical) produce (Stockdale *et al.*, 2001). However, the US Secretary of Agriculture while announcing the National Organic Programme during 2000 had stated, "Let me be clear about one other thing. The organic logo is a marketing tool. It is not a statement about food safety. Nor is 'organic' a value judgment about nutrition or quality (Hollyer *et al.,* 2013). And as per the organic standards also, an organic produce cannot be labeled as healthier, nutritious or tastier.

Myths of better taste, improved quality and higher nutritive value, generally attached with organically produced foods, have been argued and found to lack a scientific basis (Chhonkar and Dwivedi, 2004; Woese *et al.,* 1997). However, several studies (Walia and Kler, 2009; Kaur *et al.,* 2006) have reported the better quality of organic products than conventionally grown products. The average level of minerals, in a study at Chicago, were much higher (Calcium 63, Iron 73, Magnesium 118, Molybdenum 178, Phosphorus 91, Potassium 125 and Zinc 60%) in organically grown than in the conventionally grown food (Anon, 2004). There is ample, but circumstantial, evidence that on an average, organic vegetables contain more of defense related compounds such as minerals, vitamins, protein and carbohydrates, allowing for the possibility that organic plant foods may in fact benefit human health more than conventional ones (Brandt and Molgaard, 2001). Organically grown vegetables contained significantly more vitamin C, iron, magnesium and phosphorus (Worthington, 2001). Organic rice had better physical grain quality (Surekha *et al.*, 2010) and straw berries, black berries and corn had 19, 50 and 58% higher anti-oxidants, respectively than conventional crop (Duram, 2007). Vora (2009) reported higher amounts of Ca, Mg, K, Na, Mn, Fe and Cu in organically grown garden vegetables than the commercially grown which had only 13% of the minerals of the organically grown vegetables. The quality of organic produce in terms of aroma, essential oil content, texture, taste and shelf life have been reported to be superior by Leclare *et al.* (1991) and Sharu and Meerabai (2001). High protein and sulphur containing amino acids were reported in organic soybean by Singh *et al.* (2011). Higher protein and mineral content were found in okra grown with FYM as compared to commercial manures (Bhadoria *et al.*, 2002). Organic management improves quality (higher vitamins and nutrients) of fruit and vegetable crops and also helps minimize the toxic chemical load (Lairon, 2010). Few researchers have concluded that the organic production improves the quality of rice (Bourn and Prescott, 2002; Saha *et al.*, 2007), while others have failed to establish any significant change in quality parameters. However, Dixit and Gupta (2000) reported improved rice quality under organic farming.

In general, organic rice is low in protein content than conventionally grown rice (Worthington, 2001). Saha *et al.* (2007) and Kharub and Chander (2008) also reported reduction in grain protein in organic practices compared to inorganic fertilization. Though, low protein organic rice turns softer after cooking and is normally preferred over high protein conventionally grown rice (Tamaki *et al.*, 1989; Kaur *et al.*, 2015), the palatability of organic rice is generally low given its reduced protein content.

Significant reduction in grain amylose content in organic rice has been reported by Kaur *et al.* (2015). After cooking, organic rice generally has lower gruel solid loss and higher elongation and width expansion ratio. Also, milled organic rice exhibits significantly higher length/breadth (L/B) ratio and kernel weight but has low bulk density as compared to conventional rice (Kaur *et al.*, 2015). Dixit and Gupta (2000) in a study at Kanpur (UP) reported higher protein and amylose content in organically grown rice as compared to inorganic rice.

Krejcirova (2006) reported lower crude protein content in organic wheat (10.1%) as compared to inorganic wheat (11.6%). Nitika (2008) also reported lower protein content in organic wheat (12.8%) than inorganic wheat (14.8%) but fat content, total sugar, reducing sugar and non reducing sugars were higher in organically grown wheat than inorganic wheat.

Various sources claim better quality of organic products by virtue of higher nutrients and antioxidants. The concentrations of a range of antioxidants such as polyphenolics were found to be substantially higher in organic crops/crop-based foods, with those of phenolic acids, flavanones, stilbenes, flavones, flavonols and anthocyanins being estimated 19, 69, 28, 26, 50 and 51% higher, respectively. Many of these compounds have previously been linked to a reduced risk of chronic diseases, including CVD and neuro-degenerative diseases and certain cancers, in dietary intervention and epidemiological studies. The frequency of occurrence of pesticide residues was found to be four times higher in conventional crops, which also contained significantly higher concentrations of the toxic metal Cd (Baranski *et al*., 2014). A study at ICAR-IIFSR, Modipuram through Network project on organic farming indicated slight to moderate improvement in protein content of soybean, groundnut, maize and dolichos bean under organic management, compared to conventional management with full NPK dosage. Piperin content of black pepper was significantly higher under organic management (Anon, 2011).

The organic does not mean healthier always as higher percentages of *E. coli* positive samples were found in organic produce as compared to conventional food in a study by university of Minnesota (Mukherjee *et al.,* 2004).

Economic considerations

The profitability of organic farming depends upon factors like skill of individual, climate, general price level, amount of land available and price premiums (Offermann and Nieberg, 2002). The economics of organically produced crops vis-à-vis conventionally grown crops does not follow a consistent trend and it vary from crop to crop and region to region. It may be a low cost production system if grown with limited on-farm inputs but it may not be as remunerative as the conventional grown crop due to lower yield. The controversy over profitability of organic farming arises basically due to quantities and price considerations of organic inputs. If market price of organic inputs is taken into account then it becomes a low remunerative proposition. If crops are to be supplied with proper required nutrition through manures and composts and are to be protected from pests and diseases through biopesticides then its cost of production becomes prohibitive (Narayana, 2011).

Organic farming in spite of the reduction in crop productivity provides higher net profit to farmers compared to conventional farming due to the availability of premium price (20-40%) for the certified organic produce and reduction in the cost of cultivation (Ramesh *et al.,* 2010). However, Kumari *et al.* (2010) and Kharub and Chander (2008) reported higher profit from conventionally grown crops compared to the organically grown crops. Higher net returns from potato under recommended chemical fertilizers than organic source were reported in Meghalaya by Baishya *et al.* (2010) which otherwise is considered to be a potential area for organic farming. However, incorporation of crop residues of crops + green manuring + phosphorus solubilizing microbes + poultry manure 5 t/ha + neem cake 0.2 t/ha, resulted in higher yield and net returns than inorganic management in rice-wheat system (Yadav *et al.,* 2009). Singh (2010) also reported higher net returns from organic rice and wheat as compared to conventional crops. Panneerselvam *et al.* (2011a) in a comparative study of organic and conventional farming systems in Uttrakhand, Madhya Pradesh and Tamil Nadu concluded that cost of production was lower with organic farming without having any adverse effect on the total farm production. Production costs of organic crops are generally higher than conventional crops due to labour costs involved in application of organic manures and manual weedings. The cost of manual weeding in rice is about 6 times and wheat about 1.5 times more than that with herbicides (PSFC, 2008).

Organic standards and certification

Organic standards are the minimum requirements that must be met during the production, processing, storage and transportation of organic products where as organic certification is a procedure to ensure the compliance of organic standards during all these stages. Certification is a third party guarantee to the consumer regarding the authenticity of organic produce. An institutional mechanism for the implementation of standards for organic production and certification is provided through a National Accreditation Policy and Programme in India. It provides the means of evaluation of certification programmes for organic farming and products as per the approved criteria and accredited certification programmes. It facilitates certification of organic products in conformity to the standards laid down for organic products and also encourages the development of organic farming and organic processing. Currently, there are 28 certification agencies in India (APEDA, 2017). The series of events that led to development of organic farming in India are given in Table 3.

Table 3. Major developments of organic farming in India

Event	Year
First conference of NGOs on organic farming in India by the Association for Propagation of Indigenous Genetic Resources (APIGR) at Wardha	1984
Sevagram declaration for promotion of organic farming in India	1994
National Programme for Organic Production (NPOP)by APEDA	2001
National Standards for Organic Farming	2004
Network Project on Organic Farming	2004
National Project on Organic Farming by Ministry of Agriculture	2004
National Centre of Organic Farming at Ghaziabad (UP)	2004
Nagaland state declared intention to go organic and defined organic pathway and policy	2007
Launching of Sikkim Organic Mission	2010
Network Project on Organic Farming in Horticulture crops	2013
Paramparagat Krishi Vikas Yojana	2015
Mission Organic Value Chain Development-NEH region	2016
Sikkim becomes first organic state in India	2016
Launch of Participatory Guarantee System (PGS) of certification	2016

Organic farming scenario

Currently, there is 43.7 million ha area under organic management in 172 countries of the world which is 0.99% of the world's agricultural land. The regions with the largest areas of organic agricultural land are Oceania (17.3 m ha), Europe (11.6 m ha) and Latin America (6.8 m ha). Australia has the highest organic agricultural land followed by Argentina and the United States. The percent area under organic farming is the highest in Falkland Islands (36.3%) followed by Liechtenstein (30.9%) and Austria (19.4%). India has the largest number of organic producers (6, 50,000) followed by Uganda (1, 90,552) and Mexico (1, 69,703). The major driving force in promotion of organic farming is the demand for organic foods. The global sales of organic products reached 80 billion USD in 2014 from 15.2 billion USD in 1999. The countries with the largest markets are the US, Germany, and France but the highest per capita consumption is in Denmark followed by Switzerland and Austria (Willer and Julia, 2016).

In resonance with the global trends, the area under organic cultivation in India has also increased to 5.71 million ha during 2015-16 (Fig 1; Table 4).

Prospects in India

India, with a total area of 142 million ha under cultivation, has 68% area under rainfed cultivation which spreads to 177 districts covering 86 million ha. In these areas, the use of synthetic fertilizers not only increases water demand of crops but also reduces water holding capacity of already light soils (Faroda *et al.,* 2008). The rate of fertilizer application, due to erratic rainfall, is very low (36.4 kg/ha) as compared to national average of 76.8 kg/ha (FAI, 1998). The farming systems are highly diversified with crops, trees, animals, grasses etc and on an average there are 10-30 trees per ha and each family has 2-5 farm animals. Thus, low fertilizer use and diversified farming systems make a strong point in favour of going organic in these areas which is also not likely to affect the national food security. Rich traditional wisdom in these areas for restoration of soil fertility and for pest control further strengthens and provide strong infrastructure for organic system (Sharma and Goyal, 2000). Diversified cropping systems are pre-requisite of organic farming systems and thus organic farming has the potential to diversify rice-wheat in green revolution region but on a small scale.

The shrinking fossil fuel reserves and associated price escalation of agro-inputs associated with withdrawal of subsidies will certainly make a positive case for influencing a conventional farmer towards organic farming provided organic food markets with premiums on organic produce are established. However, keeping in view the contribution of food grains to central pool, complete shift to organic farming is neither desirable nor possible in high input use areas. Systematic phasing out of use of agrochemicals and synthetic fertilizers may be a step in right direction. This can be achieved by adopting the Good Agricultural Practices (GAP) but the limitation is that the farmers do not get any financial benefit by adopting GAP. So there is a need to have a certification mechanism such as IndiaGAP certification so that the farmer may get small premium on this certified food and consumer safe food at affordable price.

Farmers' perceptions

A study conducted in Madhya Pradesh revealed that 67% of respondents had positive perception towards organic farming (Patidar and Patidar, 2015). The farmers were interested in converting to organic farming in the near future due to the low cost of production in Madhya Pradesh and

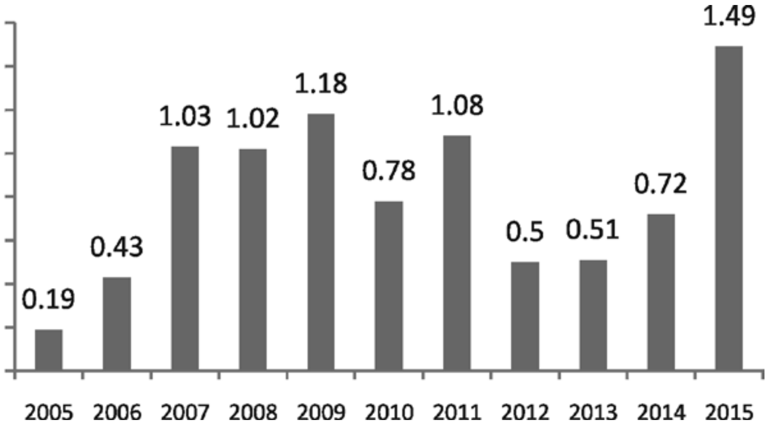

Fig 1. Area (mha) under organic cultivation in India

Table 4. Status of organic farming in India (2015-16)

Total area under organic farming	5.71million ha
Cultivated area under organic farming	1.49 million ha
Wild forest area under organic farming	4.22 million ha
Number of organic producers (2013)	6,50,000 (Highest in the world)
States having highest area under organic farming	Madhya Pradesh
Organic production	1.35 million ton
Organic exports	2,63,683 ton (298 million USD)
Topmost exported organic item	Oilseeds
Largest contributed organic product in global market	Cotton

Source: APEDA, 2017

due to the price premium and health benefits in Tamil Nadu and Uttarakhand. Low yields and pest control were the major concerns. However, organic farms in Madhya Pradesh and Uttarakhand experienced yield increases because most of the farms were in the post-conversion period, while the farms in Tamil Nadu were in the conversion period and experienced yield reduction (Panneerselvam *et al.,* 2011b).

Consumer perceptions and preferences

Consumer, worldwide, is becoming health conscious and is concerned about nutrition. AC Nielsen, a leading market research firm, recently surveyed about 21,000 regular internet users in 38 countries to find their preference for functional foods- foods that have additional health benefits. The survey revealed that India was among the top ten countries where health food, including organic food, was in demand by the consumers. A study by Ragavan and Mageh (2013) in Chennai city (Tamil Nadu) shows that perceptions towards organic food product depict the strongest relationship with buyers' intention to buy organic food product followed by the buyers' belief that consuming organic food product is contributing to preserving the environment. It seems that perception towards organic food and belief that organic food is environment friendly are not independent from each other. Besides, the availability of product information is also supporting the consumers' intention to purchase organic products. The perception towards organic products, beliefs about product safety for use, belief about product friendliness to the environment and availability of product information are the major determinants for the consumers' purchase intention towards organic products. The results indicate that about 15.3% of the consumers are regular buyers of organic products followed by occasional buyer (14.7%), started again buyer (8%) and non-buyer (62%). Hence, it is inferred that just more than one third of consumers are buyers of organic products.

A study by Radhika *et al.* (2012) clearly indicates that 53% of the respondents agreed that they liked the organic but it was expensive, however 41% were neutral and 7% disagreed that it was expensive. While buyers of organic food like to try new categories, they are yet to feel convinced enough to completely overhaul their purchase patterns. The typical product categories that they prefer to purchase are usually perishable goods– fruits & vegetables and dairy products (Technopak, 2012). This pattern hints towards consumers' concern regarding the quality of regular varieties currently available in these categories– as fresh products. The need for 'freshness' and 'quality' is paramount in consumers' minds.

Constraints in adoption

No doubt, the advantages of organic farming outweigh its disadvantages but in practical it has several constraints. The major constraint, at the policy level, in the adoption of organic farming is threat to national food security as India needs 276 million ton of food grains by 2020. A practical limitation is low organic carbon status of soils in the country where as for successful organic farming it should be above 1.2% (Paul *et al.,* 2010). Lack of awareness about organic products among the consumers and organic agricultural practices among the farmers is also a limitation. The farmers are not aware of the biofertilizers, biopesticides and organic standards. Organized marketing mechanism with price premium for organic products is lacking. The small and marginal farmers, who can adopt this system easily, are unable to market their organic produce.

Certification of organic farms is a complex and costly process which the small and marginal farmers cannot afford. Though, a zero cost 'Participatory Guarantee System (PGS)' of certification has been introduced but it is only for domestic market.

None or less availability of organic manures and composts is also a major limitation in adoption of organic farming. As the farmyard manure (FYM) from the commercial dairies is not allowed so the organic farmer has to arrange FYM at his own farm for which he has to rear dairy animals and shift farm land to organic fodder production. On an average, there are 2 animals/ha in Punjab and to supply recommended dose of nitrogen to one hectare of rice and wheat through farmyard manure it would require about 17 animals/ha (PSFC**,** 2008). Green manuring, an important component of organic farming, has also a limited appeal for extra cost on its raising and no monetary returns. If crops are to be supplied with recommended nutrients through manures and composts and are to be protected from pests and diseases through biopesticides then its cost of production becomes prohibitive. Inconsistent performance of biofertilizers is a rule rather an exception which hinders their mass acceptance and large scale adoption. The non-availability of quality biopesticides, having a satisfactory shelf life, for pest and disease management is a limiting factor. Organic farming being more labour intensive provides increased employment opportunities (Rajasekharan, 1995) but this is a limitation in areas with labour shortage. Majority of farmers in Punjab think that organic farming is a laborious and time consuming (Aulakh *et al.***,** 2009; Kaur, 2004).

Conclusion

The adverse effects of modern agriculture are not because of the modern agricultural technologies rather their misuse. The overuse of agrochemicals in gross violation of the recommendations of research institutions is resulting appearance of pesticide residues in agricultural produce. There is need to modify agricultural practices by adoption of environment friendly practices like integrated crop and pest management to conserve and enhance the ecological foundations such as soil, water and biodiversity essential for sustained advances in agricultural productivity and profitability (Swaminathan, 2010). Organic farming systems are very much native to India as traditionally crops and livestock have been reared together and even as of today also, they are present in more than 85% of the farm households. However, it may not be feasible to sustain high level of production to meet the food grain supply for the ever-increasing population (Tarafdar *et al.*, 2008). Out of the total organic resources likely to be available in 2025, the considerable tapable potential of nutrients ($N+P_2O_5+K_2O$) from human excreta, livestock-dung and crop residues has been worked out to be only 7.75 million ton. Moreover, the human excreta are not allowed on organic farms. Thus, integrated approach of crop management ('towards organic') would be appropriate in the states contributing major share to the national food basket.

Organic production of niche crops (crops having high yield potential under organic management and market demand) can be considered in the hilly and rainfed areas. Total factor productivity (TFP) growth score prepared by National Institute of Agricultural Economics and Policy Research has revealed that technology-driven growth has been the highest in Punjab and the lowest in Himachal Pradesh. It implies that some of the states like Himachal Pradesh, Uttarakhand, Madhya Pradesh, Rajasthan, Jharkhand and north-eastern region of India have not been influenced much by the modern inputs of agriculture like chemical fertilizers and pesticides and can be the potential areas for organic farming. However, organic farming technologies need to be fine-tuned and updated to further enhance the crop yields. Farmer friendly certification policies and supply-demand chain management is essential for the growth of organic farming in the country. Integration of tradition, innovation and science in the de-facto organic areas (hills) and rainfed/dryland regions will contribute to safe food security besides increasing the farm household income and climate resilience. This differential region specific approach will contribute positively to the cause of human, livestock and eco-system health.

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