International Journal of Plant & Soil Science

32(4): 35-50, 2020; Article no.IJPSS.56325
ISSN: 2320-7035

Organic Farming: Prospects, Constraints, Opportunities and Strategies for Sustainable Agriculture in Chhattisgarh - A Review

S. P. Singh[1*], Chanchala Rani Patel[1] and K. K. Paikra[1]

[1]*Krishi Vigyan Kendra, Raigarh-496001, Indira Gandhi Krishi Viswavidyalaya, Raipur (C.G.), India.*

Authors' contributions

This work was carried out in collaboration among all authors. Author SPS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CRP and KKP managed the analyses of the study. Author KKP managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2020/v32i430267
Editor(s):
(1) Dr. Sangita Sahni, Dholi, Dr. Rajendra Prasad Central Agricultural University, India.
Reviewers:
(1) Malik Asif, SKUAST, India.
(2) Shipra Jha, AIB, Amity University, India.
(3) Bhupen Kumar Baruah, JB College, Jorhat, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/56325

Review Article

Received 19 February 2020
Accepted 25 April 2020
Published 06 May 2020

ABSTRACT

Organic farming is a sustainable agriculture production system is being followed from ancient times in India. The natural resource management and biodiversity conservation is a core principle of organic agriculture. During post independence, the most important challenge in country has been to produce enough food grain for the growing population. Hence, high-yielding production system contributing to concerns of soil health, agrosphere, environmental pollution, chemical fertilizers, agrochemicals and sustainability of agricultural production. This process involves the use of biological wastes (crop, animal and farm wastes, aquatic wastes), biological materials, avoiding synthetic substances to maintain soil fertility and ecological balance thereby minimizing environmental pollution. Organic farming is a farming system that involves growing and nurturing crops without the use of synthetic fertilizers and pesticides. Also, no genetically modified organisms are permitted. The primary aim of organic farming is to keep the soil alive in good health through the use of biological wastes and other biological materials along with beneficial microbes to release macronutrients and micronutrients to crops for increased sustainable production in an eco friendly

**Corresponding author: E-mail: spsinghsahab@gmail.com;*

pollution free environment. Organic farming provides quality food is beneficial to human health and practice keeps the environmental friendly. The production of these organic crops is reviewed with regard to sustainable agriculture in Chhattisgarh.

Keywords: Organic farming; sustainable agriculture; climate change; cost-benefit analysis.

1. INTRODUCTION

Organic farming is an alternative agricultural system which originated early in the 20th century in reaction to rapidly changing farming practices. Organic producers of the world, out of which India has 0.83 million producers. The total agricultural area dedicated to organic farming in Asia was approximately 4.9 million hectares in 2016. In 2016, India ranked 1st in terms of organic producers with 8.35 lakh (13.5%) and 3rd in terms of organic area under cultivation with 4.2 million hectare (10.5%) of the world. Worldwide only 0.7% of the organic land was devoted to the cultivation of vegetables, while India offered 14.3% of its organic area for vegetable cultivation in 2016. In 2009-10, fruits and vegetables (30%) together had the largest organic share in India's crop production. Total area registered under National Programme for Organic Production of India was 3.56 million hectares in 2018. This included 1.78 million hectares (50 per cent) under organic crop production and 1.78 million hectares under wild harvest collection. India ranks 9th in terms of world's organic agricultural land and 1st in terms of organic agricultural producers. India exported about 21.27 million tonnes of total agricultural produce (Rs. 1,084 billion in value) including rice, animal products and fresh vegetables and fruits and exported around 0.31 million tonnes of organic products worth Rs. 24.77 billion in 2016-17. In 2016, globally the total area under organic vegetable cultivation (0.43 million hectares) was 0.7 per cent of the total area under vegetable cultivation (62 million hectares) and 4.3 per cent of the 10.6 million hectares available for organic farming. With respect to 2015, the area under organic vegetable cultivation witnessed a slight increase of 0.7 per cent during 2016. In 2010, India exported 143 MT of organic vegetables (0.24 per cent of the total organic produce exported), while 5000 MT (20 crores) of organic fruits and vegetables were consumed domestically. In Chhattisgarh, it occupied 4,113 ha under organic vegetables, rice, wheat and pulses so we are able to conclude that the organic vegetable production has been following a rising trend [1]. Organic farming management is an integrated approach, where all aspects of farming systems are interlinked with each other and work for each other. A healthy biologically active soil is the source of crop nutrition, on-farm biodiversity controls pests, crop rotation and multiple cropping maintains the system's health and on-farm resource management with integration of cattle ensure productivity and sustainability. Since organic farming means placing farming on integral relationship, we should be well aware about the relationship between soil, water and plants, between soil, soil microbes and waste products, between the vegetable kingdom and the animal kingdom, between agriculture and forestry, between soil, water and atmosphere etc. FAO suggested that "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs". According to the International Federation of Organic Agriculture Movement [2] the major objectives of organic farming include: (1) production of high quality food in sufficient quantity in harmony with natural systems and cycles, (2) enhancing biological cycles within the farming system involving microorganisms, soil flora and fauna, plants and animals, (3) maintaining long-term soil fertility and genetic diversity of the production system and its surroundings including plant and wild life, (4) promoting healthy use with proper care of water resources and all life there in, (5) creating harmonious balance between crop production and animal husbandry, and (6) minimizing all forms of pollution. It emphasizes, the use of management practices in preference to the use of off –farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system [3]. This system makes use of organic wastes and crops are raised in such a manner that it keeps the soil healthy and alive. Microbes are used as bio-fertilizers to increase production without polluting the environment. The key characteristics include protecting the long-term fertility of soils by maintaining organic matter levels, fostering soil biological activity, careful mechanical intervention, nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, effective recycling of organic materials including crop residues and livestock wastes and weed, and diseases and pest control relying primarily on crop rotations, natural predators, diversity, organic manuring, and resistant varieties. A great emphasis is placed to maintain the soil fertility by returning all the wastes to it chiefly through compost to minimize the gap between NPK addition and removal from the soil [4]. Today, the burgeoning population pressure has forced many countries to use chemicals and fertilizers to increase the farm productivity for meeting their ever-increasing food requirements. The prolonged and over usage of chemicals has, however, resulted in human and soil health hazards along with environmental pollution. The key factors affecting consumer demand for organic food is the health consciousness and the willingness of the public to pay for the high-priced produce. In Europe, government policies aim to stimulate the organic sector through subsidies, consumer education, and support in the form of research, education, and marketing. Agricultural practices of India date back to more than 4000 years, and organic farming is very much native to this country. As mentioned in *Arthashastra*, farmers in the *Vedic* period possessed a fair knowledge of soil fertility, seed selection, plant protection, sowing seasons, and sustainability of crops in different lands [5]. The key issues emerging in organic farming from literature review include yield reduction in conversion to organic farm, soil fertility enhancement, integration of livestock, certification, ecology, marketing and policy support. After almost a century of development organic agriculture is now being embraced by the mainstream and shows great promise commercially, socially and environmentally. While there is continuum of thought from earlier days to the present, the modern organic movement is radically different from its original form. It now has environmental sustainability at its core in addition to the founders concerns for healthy soil, healthy food and healthy people.

2. PROSPECTS

India has traditionally been a country of organic agriculture, but the growth of modern scientific, input intensive agriculture has pushed it to wall. But 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 address the quality and sustainability concerns, but also ensures a debt free, profitable livelihood option. Although, commercial organic agriculture with its rigorous quality assurance systemis a new market controlled, consumer-centric agriculture system world over, but ithas grown almost 25-30% per year during last 10 years. In spite of recession fears the growth of organic is going unaffected. Consumers concern over high levels of saturated fats, sugarcane, salt in foods as well as the risks from additives and pesticide residues, has stimulated the demand for health foods particularly organic foods. At the same time, especially in Europe have resulted in encouraging organic farming where in the yield levels are low resulting in reducing the supply. Even though the above factors have contributed to the growth of market for organic food, it is interesting to note that there have been no major promotion campaigns in catering organic food. In this context, marketing concepts needs to be prominent but cannot dominate totally. The key factors affecting consumer demand for organic food is the health consciousness and the willingness of the public to pay for the high-priced produce. India is poised for faster growth with growing domestic market. Success of organic movement in India depends upon the growth of its own domestic markets. The concept of organic farming has strong marketing appeal, growth forecasts are almost all positive and it has been suggested that the ‘movement’ is now an ‘industry’ [6]. Organic agriculture is one of the fastest growing agribusiness sectors in the world, with double-digit annual growth in land under organic cultivation, value of organic produce and number of organic farmers. There are about 26 million hectares of organic farmland currently and the global market value of organic goods. National Programme on Organic Production (NPOP) defined its regulatory framework; the National Project on Organic Farming (NPOF) has defined the promotion strategy and provided necessary support for area expansion under certified organic farming. Growing certified area before the implementation of NPOP during 2001 and introduction of accreditation process for certification agencies, there was no institutional arrangement for assessment of organically certified area [7]. Initial estimates during 2003-04 suggested that approximately 42,000 ha of cultivated land were certified organic. By 2012 India had brought more than 11.2 million ha of land under certification [8]. India has also achieved the status of single largest country in terms of total area under certified organic wild harvest collection.

3. CONSTRAINTS

Total geographical area of India (328.7 m ha), about 80% (264.5 m ha) is under agriculture, forestry, pasture and biomass production [9]. Our country supports approximately 16% of the world's human population and 20% of the world's live stock population on merely 2.5% of the world's geographical area. The steady growth of human population coupled with fastened developmental activities exerts heavy pressure on India's limited land resource and cause severe land degradation. According to latest estimates [10], about 184.8 m ha of land (57% of total land area) has been degraded due to various reasons. Groundwater depletion occurs in regions intensively irrigated by tube wells [11]. The rate of loss of soil organic carbon (SOC) and total nitrogen (TN) in surface soil horizon decreases with time in cultivation. Over 10.9 m ha of permanent pasture contains 42 animals per hectare for grazing against the threshold level of 5 animals per hectare [12]. Over grazing and massive extraction of fodder increase compaction and reduces infiltration and ultimately changes the soil quality. Most parts around metro polish and industrial areas are witnessing massive release of solid and liquid waste. In addition, India is witnessing open cast mining in many of its geographical regions with consequent increases in soil pH, Mg: Ca ratio, bulk density, clay dispersibility, total magnesium and calcium carbonate and decreases in soil porosity and available phosphorous [13].

Water quality: According to the National Water Quality Inventor report, compared to the point sources, agricultural non-point sources (NPS) are the leading contributor to water quality degradation of rivers and lakes. Agricultural activities as non-point source of pollution include Sedimentation, eutrophication, salinization through irrigation in arid areas and addition of pesticides and heavy metals to downstream, lakes and rivers through runoff. Further, the quantity of fertilizer use, type of farming practices and crop species also affect the ground water quality. From organic farmlands, nutrient loss to run-off is considerably low.

Irrigation: Industrial and municipal wastewaters containing toxic metals such as Zn, Cu, Pb, Mn, Ni, Cr, Cd are increasingly being used for irrigating crops especially in urban and peri-urban areas of developing countries due to easy availability, disposal problems and scarcity of unpolluted fresh waters. Regular irrigation of crop land with sewage and industrial waste water may cause heavy metal accumulation in soil [14] and vegetables [15] and degrades soil quality [16]. In a study at Rajasthan, conducted by [17], plants irrigated with waste water accumulated 116–378 mg kg^{-1} Fe, 12–69 mg kg^{-1} Mn, 5.2–16.8 mg kg^{-1} Cu and 22–46 mg kg^{-1} Zn. In a study at Varanasi, continuous application of treated waste water was found to cause accumulation of Cd (1.55 - 13.80 µg g^{-1}), Pb and Ni (10.45 -39.25 µg g^{-1}) exceeding their safe limits [15,18] have reported heavy metal contamination of Ganges, the major river system of north India, and suggested that regular irrigation could lead long standing health risk to consumers.

Atmospheric deposition: Atmospheric deposition of pollutant aerosols is rising in many parts of the world including India [19]. High atmospheric depositions of heavy metals and increased accumulation in crops and vegetables have also been reported in India [20]. Atmospheric deposition of toxic metals could affect human health and plant performance directly or through soil and food chain associated routes [21]. Deposition of heavy metals not only leads to multifold accumulation in tomato, egg plant, spinach, amaranthus, carrot and radish but also cause significant damage to soil microbial activity in organically amended soil. Thus, deposition of heavy metals may compromise organic farming's ability of stabilizing soil fertility and providing toxin-free produce.

Livestock resources: Livestock resources have played multifaceted roles strengthening indigenous agricultural practices and generating income and livelihoods for large masses of rural dwellers in India. However, with the advent of technology in agriculture, livestock population in our country is rapidly declining. Advent of technology in agriculture coupled with inadequate feed supply are the major determinants reducing attraction of common people towards livestock production, and thus the availability of manure, even to small farm holders. The area under natural pasture in India is rapidly declining as a result of expanding urban and agricultural areas. For maintaining soil fertility and meeting crop nutrient demands, large quantity of organic supplements are needed and accordingly, appropriate farm-scale management strategies considering cultural and socio-economic environment of farm holders are required. In particular, lack of sufficient amount of vermicompost and non-availability of biofertilizers in local market further constrain organic producers [22]. In India, most of the crop residues are removed from the fields for use as fodder and fuel. Thus, adoption of mulch farming technique as a potential tool to conserve soil organic matter content to sustain biomass/agronomic yield is possible if cost effective alternate sources of fodder and fuel are identified and made available at large scale.

Certification: Access to certification, cost involved therein and a time lag of three years (conversion stage) often constrain farmers especially small land holders in India from adopting organic farming. Organic produce needs certification to ensure that all synthetic inputs are prohibited and soil building approaches are followed. The certification process aims at converting the growing area to comply with requirements of standard within a period of three years. For this reason, farmers who adopt organic management need to wait for up to three years under certification procedures that requires purging of chemical residues. In India, the Director General of Foreign Trade, New Delhi, permits the export of organic produce provided that these are produced, processed and packed under a valid organic certificate issued by a certification agency accredited by an accreditation agency designated by the Government of India. The Government of India has recognized Tamil Nadu Organic Certification Department, Agricultural and Processed Food Products Export Development Authority (APEDA), Spice Board, Ministry of Commerce and Industry, Coffee Board and Tea Board for the purpose. However, lack of knowledge, rationale capital and access to certification discourage small farm holders in developing countries including India. Major issues that constrains farmer’s acceptance in India include: cost benefit anomalies, access to certification, non - availability of organic supplements and lack of appropriate knowledge to RMPs. Yield declines during first year of conversion and steadily increases in subsequent crop cycle. Once the farm is established organic, the yield enhances and the cost of production declines. Accordingly, there may be a deficit in net income under organic farming compared to conventional one up to third year. As input cost declines, the net income increases progressively fourth year onward [23]. However, the three initial year deficit coupled with certification associated constraints often make small farm holders apprehensive.

4. OPPORTUNITIES

A substantial amount of global CO_2 comes from soil through decomposition, mineralization and soil respiration [24]. Conventional agricultural practices that most often accelerate these processes can substantially influence atmospheric C balance on global scale. The mechanism and potential of C-sequestration in converted ecosystems are still not well understood and probably for this reason, predictions made for global carbon balance remain uncertain [25]. The soil C pool reflects a balance between the input and output and if the carbon flux is low relative to storage it leads sequestration in soil but a higher flux cause C loss. As per [26] report, soil carbon sequestration holds the greatest global C mitigation potential. Most agricultural soils have lost 30% to 70% of their antecedent SOC pool [27]. Soil carbon sequestration is cost effective and may contribute to about 89% of total C mitigation [28]. FAO has prepared a Global Carbon Gap Map that identifies areas of high carbon sequestration potentials [29]. India, representing almost all major climatic zones and wide range of land use systems, has vast opportunities for soil carbon sequestration. Conversion of natural to agricultural ecosystems causes depletion of SOC pool by as high as 60% in soils of temperate regions and over 75% in cultivated soils of the tropics [30]. Since the soil C can have a stable and long residence time, even hundreds to thousands of years under many circumstances [31], the conversion of plant sequestered C to soil organic C could play a crucial role. Soil is an ideal reservoir organic C, however land degradation could lead to loss of 30-40 Mega gram C ha^{-1} in cropland and 40- 60 Mega gram C ha^{-1} in degraded soils [32]. Among the major determinants regulating C-flux or storage in soil include climate (especially temperature), soil moisture, microbial biomass and quantity and the quality of natural and added organic inputs [33]. Although the major goal of any agricultural practice is to enhance crop yield, recent global attention has focused serious attention to link agricultural management strategies with C–sequestration and sustainability of agro-ecosystems [28]. Sequestration of C may be in the forms of soil organic carbon (SOC) and soil inorganic carbon (SIC). Common recommended management practices (RMPs) include mulch farming, conservation tillage, agro-forestry, diverse and intercropping systems, crop rotation, cover crops, and integrated nutrient management including the use of manure, compost, biosolids, improved grazing, and forest management [32]. Further, many agricultural activities enhance GHG emissions [34]. Rice is an important crop in India constituting over 42.5% of the area under cereal cultivation [35]. Chhattisgarh state is popularly known as "**Rice bowl of India**" because maximum area is covered under rice during *kharif* and contribute major share in national rice production. Rice is cultivated under flooded condition and the anaerobic condition created during rice cultivation leads to emission of CH_4 and N_2O [36]. A recent study conducted in Punjab indicated that organic amendment can significantly reduce methane emission from rice field [37]. Employment opportunities is one of the major issues of developing countries is the problem of unemployment especially for a large sector of less skilled group. Organic farming requires over 15% more labour than traditional farming and therefore provides rural job opportunities [38]. Some of the commonly used organic farming techniques such as strip farming, non-chemical weeding, and production, collection and transportation of organic supplements all requires significant labour. The labour scarcity and cost involved there in, may constrain adoption of organic farming in developed countries and also for cash-poor farmers in developing countries. However, for countries like India, labour as well as the cost involved therein is not a constraint. Instead, organic farming can generate employment opportunity for a vast section of rural communities. It makes farmers and farm labours busy throughout the year.

5. STRATEGIES

Organic farming is an integrated farming systems approach, where all enterprises are interlinked with each other and work for each other. A healthy biologically active soil is the source of crop nutrition, on-farm biodiversity controls pests, crop rotation and multiple cropping maintains the system's health, and on-farm resource management with integration of livestock ensure productivity and sustainability. A live, healthy soil with proper cropping patterns, crop residue management and effective crop rotation can sustain optimum productivity over the years, without any loss in fertility. A living soil can be maintained by continuous incorporation of crop and weed biomass, use of animal dung, urine-based manures (FYM, NADEP, vermicompost), biofertilisers and bio enhancers, special liquid formulations (like vermin wash, compost tea etc) for crop's duration. Important components of organic farming are biological nitrogen fixation, crop rotation, residues of crops, biopesticides, biogas slurry etc.

Multiple cropping and crop rotation: For practicing sustainable agriculture there should be rotation of crops on the same land over a period of two years or more for maintaining soil fertility and control of insects, weed and diseases. Mix cropping is the outstanding feature of organic farming in which variety of crops are grown simultaneously or at different time on the same land. In every season care should be taken to maintain legume cropping at least 40%. Mix cropping promotes photosynthesis and avoids the competition for nutrients because different plants draw their nutrients from different depth of soil. The legume fixes atmospheric nitrogen and make available for companion or succeeding crops. Deep rooted plants draw nutrient from deeper layer of soil and bring them to the surface of soil through their leaf fall. Crop rotation is the back bone of organic farming practices. To keep the soil healthy and to allow the natural microbial systems working, crop rotation is must. Crop rotation is the succession of different crops cultivated on same land. Follow 3-4 years rotation plan. All high nutrient demanding crops should precede and follow legume dominated crop combination. Rotation of pest host and non pest host crops helps in controlling soil borne diseases and pest. It also helps in controlling weeds.

Status of live organic soil: At present, most optimistic estimates show that about 25–30 percent of nutrient needs of Indian agriculture can be met by various organic sources. Supplementation of entire N through FYM sustains crop productivity at more than use of conventional N fertilizers. These organic sources besides supplying N, P, and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate the plants to absorb the nutrients. Application of organic sources encouraged the growth and activity of Mycorrhizae and other beneficial organisms in the soil and is also helpful in alleviating the increasing incidence or deficiency of secondary and micronutrients and is capable of sustaining high crop productivity and soil health [39]. Integrated use of rice straw compost + *Azotobacter* and PSB was found better than rice straw alone [40]. *Azotobacter* produced growth promoting substances which improved seed germination and growth with extended root system. It also produced polysaccharides which improved soil aggregation [41]. Seed inoculation of chickpea with *Rhizobium* + PSB (phosphate solubilising bacteria) increased dry matter accumulation, grain yield, and grain protein content in chickpea, dry fodder yield of succeeding maize, and total nitrogen and phosphorus uptake by the cropping system over no inoculation and inoculation with rhizobium alone. A fertile and live organic soil ideally should have organic C between 0.8-1.5%. At any point of time it should have adequate quantity of dry, semi decomposed and fully decomposed organic matter for the use of micro-flora and fauna. Total microbial load (bacteria, fungi and actinomycetes) should be above 1 x 10^8 gm^{-1} of soil. There should be at least 3-5 earth worms cubic ft^{-1} of soil.

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

Organic manure: The organic manure is obtained from biological sources (plant, animal and human residues). Organic manure helps in increasing crop growth directly by improving the uptake of humic substances and indirectly promoting soil productivity by increasing availability of major and minor plant nutrients through soil micro organisms.

Bulky organic manure: Bulky organic manure includes compost, FYM and green manure having less nutrients in comparison to concentrated organic manure.

Farm Yard Manure (FYM): Farm Yard Manure (FYM) refers to the well decomposed combination of dung, urine, farm litter and leftover materials (roughages or fodder).

Compost: Large quantities of waste material (vegetable refuse, weeds, stubble, straw, sugarcane trash, sewage, sludge, animal waste, human and industrial refuse) can be converted into compost manure by anaerobic decomposition.

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

Green Manuring: Green manuring is practice of adding organic matter to the soil by incorporating undecomposed green plant tissues for improving soil health. The green manure crop (legume crops) supplies organic matter and additional nitrogen. Commonly used green manure crops are sun hemp (*Crotalaria juncea*), dhaincha (*Sesbaniaa culeata*), cowpea, cluster bean, senji (*Melilotus parviflor, Vigna sinensis*), berseem (*Trifolium alexandrium*) etc.

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

Biofertilizers: Biofertilizers are micro organisms that have the capability of increasing the fertility of soil by fixing atmospheric nitrogen and through phosphate solubilization. Biofertilizers have biological nitrogen fixing organism which help them in establishment and growth of crop plants and trees, enhance biomass production and grain yields. Biofertilizers viz: *Rhizobium, Azotobacter, Azospirillum,* PSB and *Pseudomonas* etc. have been found to be very effective tools of fertility management and biological nutrient mobilization. Recently customized consortia of such biofertilizer organisms, better adapted to local climatic conditions have also been developed and are available commercially. Efficiency of such microbial formulations is much higher under no-chemical use situations, therefore application of such inputs need to be ensured under all cropping situations. There are some important and widely used bio-fertilizers.

Symbiotic nitrogen-fixation: *Rhizobium, Frankia* and *Anabaena azollae* bacteria fixes atmospheric nitrogen in roots of leguminous plants, form tumours like growth known as root nodules. These are widely used biofertilizer which can fix around 100-300 kg N ha^{-1} in one crop season.

Asymbiotic/Associative symbioticnitrogen-fixation: Blue Green Algae, *Azolla, Azotobacter, Azospirillium, Beijerinkia, Clostridium, Klebsiella, Anabaena* and *Nostoc,* grow on decomposing soil organic matter and fixes atmospheric nitrogen in suitable soil medium. *Azotobactor* has beneficial effect on vegetables, millets, cereals, sugarcane and cotton. Organism is capable of producing nitrogen as well as antifungal, antibacterial compounds, siderophores and harmones. *Azospirillium* has beneficial effect on oats, barley, maize, sorghum, forage crop and pearl millet. It fixes nitrogen by colonising root zones.

Phosphorus solubilizing bacteria (PSB): *Bacillus megaterium* var. *phosphaticum, Bacillus subtilis, Bacillus circulans* and *Pseudomonas striata,* are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds. Phosphorus solubilization ability of rhizosphere microorganisms is considered to be one of the most important in plant phosphate nutrition.

Phosphorus solubilizing fungi (PSF): *Penicillium* sp*, Aspergillus awamori* and *Fusarium*play a noteworthy role in increasing the bioavailability of soil phosphates for plant nutrition.

Phosphorus solubilizing microorganisms (PSM): *Arbuscular mycorrhiza-Glomus sp., Gigaspora sp., Acaulospora sp., Scutellospora sp.* and *Sclerocystis sp.; Ericoid mycorrhizae-Pezizellaericae; Ectomycorrhiza-Laccaria sp., Pisolithus sp., Boletus sp.*, *Amanita sp.* and Orchid mycorrhiza-*Rhizoctonia solani.* phosphate solubilizing micro organisms (PSM) could play an important role in phosphorus nutrition in many natural and agro-ecosystems.

Biofertilizers for micro nutrients: Silicate and zinc solubilizers- *Bacillus* sp.micronutrient and biofertilizers along with recommended dose of major nutrients increases the availability of the essential nutrients in the rhizosphere zone.

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

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

Azolla: Small floating fern, *Azollaharbours,* blue-green algae, anabaena, commonly seen in shallow fresh water bodies and in low land fields. They fix nitrogen in association.

Mycorrhizae: *Mycorrhizae* is symbiotic association of fungi with roots of vascular plants. This helps in increasing phosphorous uptake and improves the growth of plants.

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

Sanjivak: Mix 100 kg cow dung, 100 lit cow urine and 500 gm jaggary in 300 lit of water in a 500 lit closed drum. Ferment for 10 days. Dilute with 20 times water and sprinkle in one acre either as soil spray or along with irrigation water.

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

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

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

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

Weed management: Organic farming promotes weed management in a number of ways [42,43]. Weed growth is blocked using plastic films and the process is known as mulching. Mowing and cutting removes the top growth of weeds. Grazing is another method which helps in reducing weed growth. Organic crop rotation also promotes weed suppression [44,45]. Organic weed management promotes weed suppression, rather than weed elimination, by enhancing crop competition and phytotoxic effects on weeds. Organic farmers integrate cultural, biological, mechanical, physical and chemical tactics to manage weeds without synthetic herbicides. Organic standards require rotation of annual crops, meaning that a single crop cannot be grown in the same location without a different, intervening crop. Organic crop rotations frequently include weed-suppressive cover crops and crops with dissimilar life cycles to discourage weeds associated with a particular crop [46].

Protection to all life forms: Practice of maintaining enough biomass and mulching with crop and weed residue will ensure the protection to all life forms in soil. Another important practice of banning the chemical fertilizers and pesticides in farming definitely helps in protecting the life forms in soil. For the survivability of different life forms the field must have dry organic matter as a food for small insects and small animals in soil, semi decomposed organic matter as food for earthworms and fully decomposed organic matter for micro organisms in the soil at all times. These insects ,small animals ,earthworms and microorganisms are the tireless natural employees of the soil, wherein small animals and insects feed on the larvae of pests and thus controlling the pest ,earthworms makes the soil porous thus creating the more aerobic conditions in soil and also decompose the half digested organic residue and release locked nutrients into soil. Soil rich in organic carbon contain ample quantity of beneficial micro flora. Therefore protection to all life forms in soil should be ensured at all time.

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

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

Mechanical alternative: Removal of affected plants and plant parts, collection and destruction of egg masses and larvae, installation of bird perches, light traps, sticky coloured plates and pheromone traps are most effective mechanical methods of pest control.

Light trap- General for all nocturnal flying insects- 1 trap ha^{-1} (60 watt CFL).

Sticky trap yellow– For the monitoring of aphid, jassid, like insects. 1 trap/100 m^2 area.

Sticky trap blue - For the monitoring of thrips like insects. 1 trap/100 m^2 area.

Votta T trap- Brinjal shoot and fruit borer, Pin moth (*Tutaabsoluta*) for the monitoring 10 traps ha^{-1} and for the management 25 traps ha^{-1}.

Pheromone trap- This is a general tool which is mostly used for Lepidoptera an insects it causes damage at larval stages. For the management of adult stage of different species of Lepidoptera insects sex pheromones available in the market/company/dealers which can be used as the case is there. For the management of few of the examples are being quoted.

Biological alternative: Use of pest predators and pathogens has also proved to be effective method of keeping pest problem below ETL. Inundative release of *Trichogramma sp.* @ 40,000 to 50,000 eggs ha^{-1}, *Chelonus blackburni* @ 15,000 to 20, 000 ha^{-1}, *Apanteles*sp.@15,000 to 20,000 ha^{-1} and *Chrysoperla sp.*@ 5,000 ha^{-1}, after 15 days of sowing and others parasites and predators after 30 days of sowing, can also effectively control pest problem inorganic farming.

Bio-pesticide: Biopesticides are of plant origin and include plant products like alkaloids, phenolics, terpenoids and some secondary chemicals. They are biologically active against insects, fungi, nematodes affecting their behavior and physiology. Commonly known insecticides are Pyrethrum, Nicotine, Neem, Margosa, Rotenone etc. *Trichoderma virideae* or *T. harazianum*or *Pseudomonas fluorescence* formulation @ 4 gm kg^{-1} seed either alone or in combination, manage most of the seed borne and soil borne diseases. There is other formulations viz. *Beauvaria bassiana*, *Metarizium anisopliae*, *Numeriarileyi*, *Verticillium* sp, which areavailable in the market and can manage their specific host pest. *Bacillus thurengensis stenebrionis and B. thurengensis sandigo*are effective against coleopterans as well as some other insect species. Bt. has been used in the management of diamond back moth on crucifers and vegetables @ 0.5-1.0 kg ha^{-1}.Viral biopesticides of baculovirus group viz. granulosis viruses (GV) and nuclear polyhedrosis viruses provided a great scope in plant protection field. Spray of nuclear polyhedrosis viruses (NPV) of *Helicoverpa armigera* (H) or *Spodoptera litura* (S) @ 250 larval equivalents are very effective tools to manage the *Helicoverpa* sp.or *Spodoptera* sp. respectively.

Verticillium lecanii **-**As powder (10^7cfu/gram) 2.5 kg should be dissolved in 500 liter of water for per hectare and should be sprayed. As liquid (10^{10}-10^{12} $cfuml^{-1}$) its 1000-1250 ml should be dissolved in 500 liter of water for per hectare and then sprayed for the management of mites and insects like green hopper, leaf miner, thrips, white fly, brown hopper and other insects.

Beauveria bassiana-As powder (1x10^8 $cfugram^{-1}$) 2.5 kg should be dissolved in 500 liter of water for per hectare and should be sprayed. As liquid (1x10^{10}-1x10^{12} $cfuml^{-1}$) its 1000-1250 ml should be dissolved in 500 liter of water for per hectare and then sprayed. For the areas affected by white grubs mainly for the crop the citrus, mango and coconuts etc. 5ml of *Beauveria bassiana* per liter water to be applied .*Beauveria bassiana* @ 2 kg should be mixed with 200 liter of water dispensed through the drip or drench system to control the grubs. It can be applied on the crops like banana, soybean, paddy, oilseeds, tomato, chilli, potato, maize, sugarcane, turmeric, citrus crop, onion, garlic, floriculture and horticulture crops.

Table 1. Details of the Insects along with their lure name, associated crop and time of installation

Insect	Lure name	Crop	Time of installation
1. Rice stem borer	Scirpo lure	Rice	• One week after transplanting. • End of tillering stage
2. *Helicovera armigera*	Helli lure	Gram and different crop	• 25 days after sowing. • At flower initiation.
3. *Spodoptera litura*	Spodo lure	Different crops	• One week after transplanting. • Three weeks after sowing.
4. Spotted bollworm	Earvit lure	Okra and Cucurbitaceous	• One week after transplanting. • One week prior to flowering.
5. Diamond back moth	DBM lure	Cole crops	• One week after transplanting.
6. Brinjal Shoot and fruit borer	Leucine lure	Brinjal	• One week after transplanting. • One week prior to flowering.
7. Fruit fly	Bedor lure	Mango,Guava, Litchi	• Prior to flowering.
8.Melon fly	Baku lure	Cucurbitaceous crop	• One week prior to flowering.

Table 2. Details of the different crops, their major pests and their eco-friendly management

Crops	Major pests	Eco-friendly management through biological agents
Chickpea/ Pigeon pea/ Pea/Lathyrus /Moong/ Urad	*Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae)	• Application of *Bacillus thuringiensis* Kurstaki 8L @ 1.6 kg ha^{-1} and *Bacillus thuringiensis* Kurstaki ES @ 1.5 lt ha^{-1}, respectively, at early stages of crop infestation (1st, 2nd and 3rd instar larval infestation) with at least 2 applications at 7 days interval. • HaNPV 6x10^{9} POB/ml @ 250 lt ha^{-1}.
Mustard/ Safflower/	Aphids (*Lipaphis erysimi*).	• *Cheilomenes sexmaculata* Fabricius 5000 larvae or 500 adults ha^{-1}, • *Coccinella septempunctata* Linnaeus 5000 larvae or 500 adults ha^{-1}, Two releases; first release to coincide with the appearance of aphids
Sunflower	Aphid (*Lipaphis erysimi*).	• *Chrysoper lacarnea* (Stephens) 10,000 first instar larvae ha^{-1}.
Brinjal	Fruit and shoot borer (*Leucinodesorbonalis)*	• *Bacillus thuringiensis* 500 g ai ha^{-1} (10 days interval). • 3- 4 releases of egg parasite, *T. chilonis* @1.0 lakh ha^{-1}
Cucurbitaceous	• Fruitfly (*Bactrocera cucurbitae*) • Aphids (*Lipaphis erysimi*).	**Poison bait-** Mix Ethyl Alcohol-60ml + Methyl eugenol-40 ml + Malathion/ DDVP (Pesticide)- 20 ml (*i.e.* in the ratio of 6 :4:2). Use in Mango, Guava, Papaya, Citrus and other fruit crop. • *Cheilomenes sexmaculata* Fabricius 5000 larvae or 500 adults ha^{-1},
Okra	• Shoot and fruit borer (*Eariasvittella*) • Fruit borer (*H. armigera*)	• *Trichogramma brassiliensis* 2,50,000 parasitized eggs ha^{-1} (Inundative release) • 50,000 parasitized eggs ha^{-1} (Weekly inoculative release) • *Bacillus thuringiensis* 500 g ai ha^{-1} (10 days interval)
	• Okra aphid	• *Chrysoperlazastrowi arabica* 50,000 first instar larvae/ha (weekly release)
Tomato	Fruit borer *(Helicoverpa armigera*)	• *Trichogramma brassiliensis* 2,50,000 parasitized eggs ha^{-1} (Inundative release) • 50,000 parasitized eggs ha^{-1} (Weekly inoculative release) • *Bacillus thuringiensis*500 g aiha^{-1} (10 days interval) • HaNPV @ 250 ltha^{-1} (10 days interval)
Onion	Thrips	• *Xylocoris* • *Blaptostethus*
Potato	Potato tuber moth *Phthorimaeaoperculella*	• *Chelonus blackburnii* 50000 adults ha^{-1} in the field, Two releases at weekly intervals. • 2 adults per kg of potatoes in godowns.
Colocasia	Armyworm *Spodoptera litura* (Fabricius)	• *Trichogramma spp.*
Cabbage	DBM (*Plutella xylostella*)	• *Bacillus thuringiensis* 500 g ai ha^{-1} (10 days interval).
	Cabbage aphid	• *Chrysoperlazastrowi arabica* 50,000 first instar larvae/ha (weekly release).
Weeds	Congress grass weed	• *Zygogrammabicolorata* Pallister, one adult was

Crops	Major pests	Eco-friendly management through biological agents
	(Parthenium hysterophorus L.)	found to bring defoliation of a single parthenium plant in 6-8 weeks. Therefore, if releases are to be carried out at this rate, about 0.4. to 0.7 million insects will be required per hectare, as the weed density varies between 40 to 70 plants per square metre. In practice, it is neither possible nor necessary to release so many insects as they are capable of multiplying rapidly. Releases of about 500-1000 beetles can bring about establishment and eventual control.

Botanical pesticides: Many plants are known to have pesticidal properties and the extract of such plants or its refined forms can be used in the management of pests. Among various plants identified for the purpose, neem has been found to be most effective.

Neem (*Azadirachtaindica*): Neem has been found to be effective in the management of approximately 200 insects, pests and nematodes. Neem extracts are very effective against grasshoppers, leaf hoppers, leaf minor, plant hoppers, aphids, cotton jassids, and moth caterpillars. Neem, are also very effective against beetle larvae, butterfly, aphids and white flies, mealy bug, scale insects, adult bugs, diamond back moth. fruit maggots, spider mites, moth and caterpillars such as Mexican bean beetle and Colorado potato beetle. Neem oil @ 2.0% with 1% detergent found most effective against pod borers complex in chickpea, moong, cowpea and okra, shoot and fruit borer of brinjal. NSKE @ 5% with 1% detergent found most effective against stem borer in rice and management of diamond back moth.

Neemastra: 200 liter water + 10 liter cow urine (Desi) + 2 kg cow dung + 10 kg neem twigs with leaves + 500 gm turmeric powder + 500 gm ginger paste + 10 gm asafoetida (hing) powder mix it thoroughly and stir with wooden stick clockwise. Keep solution 48 hours in shade them filter the solution. This solution should be sprayed directly on the crop without dilution it controls sucking insects.

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

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

Fermented curd water: In some parts of central India fermented curd water (buttermilk or *Chaach*) is also being used for the management of white fly, jassids, aphids etc.

Dashparni extract: Crush neem leaves 5.0 kg, Vitex negundo leaves 2.0 kg, Aristolochia leaves 2.0 kg, Papaya (Carica Papaya) 2.0 kg, Tinosporacordifolia leaves 2.0 kg, Annona squamosa (Custard apple) leaves 2.0 kg, Pongamiapinnata (Karanj) leaves 2.0 kg, Ricinus communis (Castor) leaves 2.0 kg, Nerium indicum 2.0 kg, Calotropisprocera leaves 2.0 kg, Green chilli paste 2.0 kg, Garlic paste 250 gm, Cow dung 3.0 kg and Cow Urine 5.0 lit in 200 lit water ferment for one month. Shake regularly three times a day clockwise. Extract after crushing and filtering. The extract can be stored up to 6months and is sufficient for one acre.Karanj oil @ 2.0% with 1% detergent found most effective against pod borer complex in chickpea, moong, cowpea and okra shoot and fruit borer.

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

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

Chilli-garlic extract: Crush 1.0 kg Ipomea (besharam) leaves, 500 gm hot chilli, 500 gm garlic and 5.0 kg neem leaves in 10 lit cow urine. Boil the suspension 5 times till it becomes half. Filter squeeze the extract. Store in glass or plastic bottles. 2-3 lit extract diluted to 100 lit is used for one acre. Chilli garlic extract @ 9 kg ha^{-1} (8:1) most effective against gall midge, GLH and thrips of rice and white fly, thrips, semilooper and tobacco caterpillar of soybean, also shoot and fruit borer of brinjal along with pod borer of tomato.

Broad spectrum formulation: 1. In a copper container mix 3.0 kg fresh crushed neem leaves and 1.0 kg neem seed kernel powder with 10 lit of cow urine. Seal the container and allow the suspension to ferment for 10 days. After 10 days boil the suspension, till the volume is reduced to half. Ground 500 gm green chillies in 1 lit of water and keep overnight. In another container crush 250 gm of garlic in water and keep overnight. Next day mix the boiled extract, chilli extract and garlic extract. Mix thoroughly and filter. This is a broad spectrum pesticide and can be used on all crops against wide variety of insects. Use 250 ml of this concentrate in 15 lit of water forspray.**2.**Suspend 5.0 kg neem seed kernel powder, 1.0 kg Karanj seed powder, 5.0 kg chopped leaves of besharam (*Ipomea*sp.) and 5.0 kg chopped neem leaves in a 20 lit drum. Add 10-12 lit of cow urine and fill the drum with water to make 150 lit. Seal the drum and allow it to ferment for 8-10 days. After 8 days mix the contents and distil in a distiller. Distillate will act as a good pesticide and growth promoter. Distillate obtained from 150 lit liquid will be sufficient for one acre. Dilute in appropriate proportion and use as foliar spray. Distillate can be kept for few months without any loss in characteristics.

Certification system: In India, there are two accreditation systems for authorizing Certification and Inspection agencies for organic certification. National Programme on Organic Production (NPOP) promoted by Ministry of Commerce is the core programme which governs and defines the standards and implementing procedures. National Accreditation Body (NAB) is the apex decision making body. Certification and Inspection agencies accredited by NAB are authorized to undertake certification process. The NPOP notified under Foreign Trade and Development Act (FTDR) act and controlled by Agricultural Processed Foods Export Development Authority (APEDA) looks after the requirement of export while NPOP notified under APGMC act and controlled by Agriculture Marketing Advisor, Directorate of Marketing and Inspection looks after domestic certification. Currently 20 certification agencies have been authorized to undertake certification process. Details of the system are available at *www.apeda.com/npop*. In 2006, India's organic certification process under NPOP has been granted equivalence with European Union and Switzerland. It has also been recognized for conformity assessment by USDA's NOP.

6. CONCLUSION

Organic farming provides quality food products and fiber is beneficial to human health without adversely affecting the soil's health, socially, economically and environmentally. Organic farming in such a way, as to keep the soil alive in good health through the use of biological wastes and other biological materials along with beneficial microbes to release several plant nutrients (macronutrients and micronutrients) to crops for increased sustainable production in an eco friendly pollution free environment. There is need to identify suitable crops/products on agro climatic zone basis for conventional farming is shifting its way towards organic farming. In some agro climatic zones has great potential for organic farming and many products are produced food and nutritional security organically in India. Trading is major constraints in organic farming due to policy issues. This farming will provide ample opportunity for employment and bring prosperity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Horo Aniketa, Das Jagruti. Organic farming in India: Status and challenges with special reference to vegetables. National Seminar

"Role of Biological Sciences in Organic Farming". Journal of Pharmacognosy and Phytochemistry. 2019;Special Issue-4:09-13.

2. Willer H, Yussefi-Menzler M, Sorensen N. Available:http://orgprints.org/13123/4/world of-organic-agriculture- 2008.pdf (Last accessed on September, 2011)
3. FAO. Organic Agriculture, Food and Agriculture Organisation of the United Nations, Rome; 2002.
4. Chhonkar PK. Organic farming myth and reality, in Proceedings of the FAI Seminar on Fertilizer and Agriculture Meeting the Challenges, New Delhi, India, December; 2002.
5. Sofia PK, Prasad R, Vijay VK. Organic farming-tradition reinvented. Indian Journal of Traditional Knowledge. 2006;5(1):139–42.
6. Cornish PS, Stewart TEB. Proceedings of the 14th IFOAM Organic World Congress, 21–28 August, Victoria, Canada. Canadian Organic Growers, Ottawa. 2002;222.
7. APEDA. Annual Report 2008–09, Ministry of Commerce and Industry, Government of India, New Delhi; 2008.
8. APEDA. Annual Report 2014–15, Ministry of Commerce and Industry, Government of India, New Delhi; 2014.
9. Lal R. Soil carbon sequestration in India. Climatic Change. 2004;65:277–96.
10. SOE. The state of environment- India: 2001 report. Available:http://moef.nic.in/soer/2001 /soer.html (Last accessed on September, 2011)
11. FAO. Land degradation in South Asia: its severity causes and effects upon people; 1994. Available:http://www.fao.org/docrep/V4360 E/V4360E00.htm#Contents (Last accessed on September, 2011)
12. Sahay KB. The problem of livestock population; 2000. Acailable:http://www.tribuneindia.com/ 2000/20000411/edit.htm (Last accessed on September , 2011)
13. Sha-Sha FU, Pei-Jun LI, Qian FENG, Xiao-Jun LI, Peng LI, Yue-Bing SUN, Yang CHEN. Soil quality degradation in a magnesite mining area. Pedospher. 2011;21:98–106.
14. Zhang YL, Dai JL, Wang RQ, Zhang J. Effects of long-term sewage irrigation on agricultural soil microbial structural and functional characterizations in Shandong, China. Eur. J. Soil Biol. 2008;44:84–91.
15. Singh A, Sharma RK, Agrawal M, Marshall FM. Health risk assessment of heavy metals via dietary intake of foodstuffs from the wastewater irrigated site of a dry tropicalarea of India. Food Chem. Toxicol. 2010;48:611-19.
16. Muchuweti M, Birkett JW, Chinyanga E, Zvauya R, Scrimshaw MD, Lester JN. Heavy metal content of vegetables irrigated with mixtures of wastewater and sewage sludge in Zimbabwe: Implications for human health. Agric. Ecosyst. Environ. 2006;112:41–48.
17. Arora M, Kiran B, Rani S, Rani A, Kaur B, Mittal N. Heavy metal accumulation in vegetables irrigated with water from different sources. Food Chem. 2008;111: 811–15.
18. Pandey J, Pandey R, Shubhashish K. Air–borne heavy metal contamination to dietary vegetables: A case study from India. Bull. Environ. Contam. Toxicol. 2009;83:931–36.
19. Singh A, Pandey J. Atmospheric deposition of heavy metals in a tropical city of India.In: Gautam, S. P., (Eds.). Studies on Pollution Mitigation. Central Pollution Control Board, New Delhi. 2010;145-152.
20. Sharma RK, Agrawal M, Marshall FM. Heavy metals in vegetables collected fromproduction and market sites of a tropical urban area of India. Food Chem. Toxicol. 2009;47:583–91.
21. Pandey J, Pandey U. Atmospheric deposition and heavy metal accumulation in organicfarming system in a seasonally dry tropical region of India. J. Sustain. Agric. 2009;33:361–78.
22. Gill MS, Singh K, Walia SS. Use of Bio-fertilizers in Agriculture. Kisan world. 2000; 27:32-35.
23. IGNOU. BAPI-003 Economics and marketing of Organic produce; 2007. Available:http://vedyadhara.ignou.ac.in/wiki /images/b/bb/BAPI-003-01.pdf (Last accessed on September, 2011)
24. Jabro JD, Sainju U, Stevens WB, Evans RG. Carbon dioxide flux as affected by tillage and irrigation in soil converted from

perennial forages to annual crops. J. Environ.Manage. 2008;88: 1478–84.
25. Idso CD, Carter RM, Singer SF. Climate Change Reconsidered-2011 Interim Report.
Available:http://www.nipccreport.org/ reports /2011/pdf/2011NIPCCinterimreport.pdf
(Last accessed on September, 2011)
26. IPCC. Climate Change 2007: The Physical Science Basis.
Acailable:http://www.pnud.cl/recientes/IPCC-Report.pdf
(Last accessed on September, 2011)
27. Lal R, Follett RF, Stewart BA, Kimble JM. Soil carbon sequestration to mitigate climate change and advance food security. Soil Science. 2007;172: 943–56.
28. Smith P, Martino D, Cai Z, Gwary D, Janzen H, Kumar P, McCarl B, Ogle S, O'Mara F, Rice C, Scholes B, Sirotenko O, Howden M, McAllister T, Pan G, Romanenkov V, Schneider U, Towprayoon S. Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture. Agric. Ecosyst. Environ. 2007; 118:6–28.
29. FAO. World Food Security: The Challenges of Climate Change and Bioenergy; 2008.
Available:http://www.faopacific.ws/Portals/167/publications/Current%20Updates/WFD2008
Global report.pdf (Last accessed on September, 2011)
30. Lal R. Soil carbon sequestration impacts on global climate change and food security. Science. 2010;304:1623–27.
31. Lal R, Kimble J, Follett R. Land use and soil C pools in terrestrial ecosystems. In: Lal, R., Kimble, J.M., Follett, R.F., Stewart, B.A., (Eds.), Management of Carbon Sequestration in Soil. CRC Press, Boca Raton. 1998;01–10.
32. Wang Q, Li Y, Alva A. Cropping systems to improve carbon sequestration formitigation of climate change. J. Environ. Protect. 2010;1:207-15.
33. Trumper K, Ravilious C, Dickson B. Carbon in drylands: desertification, climate change and carbon finance; 2008.
Available:www.unep.org/pdf/Carbon-Drylands- Technical-Note. pdf
(Last accessed on September, 2011)
34. Flessa H, Ruser R, Dorsch P, Kamp T, Jimenez MA, Munch JC, Beese F. Integrated evaluation of greenhouse gas emissions (CO_2, CH_4, N_2O) from two farming systems in southern Germany. Agric. Ecosyst. Environ. 2002;91:175–89.
35. Ramanjaneyulu GV, Kuruganti K. Sustaining Agriculture in the era of Climate Change in India; 2009.
Available:http://kisanswaraj.in/wp-content/uploads/civilsocietypositionpaperwithcoverpage.pdf
(Last accessed on September, 2011)
36. Pathak H, Li C, Wassmann R. Greenhouse gas emissions from Indian rice fields: Calibration and upscaling using the DNDC model, Bio-geoscience. 2005;2: 113-23.
37. Khosa MK, Sidhu BS, Benbi DK. Effect of organic materials and rice cultivars on methane emission from rice field. J. Environ. Biology. 2010;31:281-85.
38. Pimentel D, Hepperly P, Hanson J, Douds D, Seidel R. Environmental, Energeticand Economic Comparisons of Organic and Conventional Farming Systems. Bio-Science. 2005;55:573-82.
39. Nambiar KKM, Soni PN, Vats MR, Sehgal DK, Mehta DK. AICRP on long term fertilizer experiments. Annual Reports 1987-88 and 1988-89, IARI, New Delhi, India; 1992.
40. Kalyan S. Integrated use of industrial and farm wastes with mineral and bio-activators for sustained rice productivity in rice based eco-system of Eastern Uttar Pradesh. First Annual Report, NATP, ICAR, New Delhi, India; 2003.
41. Gaur AC. Handbook of Organic Farming and Biofertilizers, AmbicaBook Publication, Jaipur, India; 2006.
42. Mameri N, Aloueche F, Belhocine D, Lounici H, Piron DL, Yahiat Y. Preparation of activated carbon from olive mill solid residue. Journal of Chemical Technology and Biotechnology. 2000; 75:625-31.
43. Gbeddy Gustav, Glover Eric, Doyi Israel, Frimpong Samuel, Doamekpor Louis. Assessment of Organochlorine Pesticides in Water, Sediment, African Cat fish and Nile tilapia, Consumer Exposure and Human Health Implications, Volta Lake, Ghana. J. Environmental and Analytical Toxicology. 2015;5:297.

44. Al-Zaidi AA, Elhag EA, Al-Otaibi SH, Baig MB. Negative effects of pesticides on the environment and the farmers awareness in Saudi Arabia: a case study. J Anim Plant Sci. 2011; 21:605-611.
45. Cizmas Leslie, Ackerman Lani, Donnelly Danielle A, Donnelly Kirby C, McDonald Thomas J. Measurement of organophosphate pesticides, organochlorine pesticides, and polycyclic aromatic hydrocarbons in household dust from Two Rural Villages in Nepal. J Environ Anal Toxicol. 2015;5:261.
46. Delate Kathleen, Hartzler. Robert. Weed Management for Organic Farmers. Iowa State University. Extension Bulletin. 2003;1883.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/56325