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Impact of organic farming on eco-friendly sustainable agriculture: A review

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Abstract
Organic agriculture completely avoid the use of chemical fertilizers and synthetic agrochemicals that's why it is eco-friendly. Use of organic manures *viz*., FYM, poultry manure, composts, green manures, oil free cakes etc., increase soil microorganisms count and activity, which improves soil health and fertility. Research has revealed that organically grown food grains and vegetables are safe than conventionally grown, which contains residues of fertilizers, agrochemicals, nitrates, metals and antibiotics causing health hazards. Organic food products are more nutritious and beneficial to health that's the reason the demand and price both are increasing day by day in the market. Thus organic agriculture has the ability to boost up the economy of small farmers.

Keywords: organic farming, eco-friendly, agriculture

Introduction
In the past few decades it becomes a tradition in agriculture to produce maximum food grain by using more chemical fertilizers, insecticides, pesticides, fungicides, weedicides and other chemicals regardless of its impact on environment and community health. Researchers, organizations and policy makers are still engaged in maximizing the food grain production per capita by applying the chemicals, fertilizers yet the food grain production is likely to double in the present scenario. Since last decade the organic forming gained attention of researchers, formers and government policy makers that's why area and production of organic forming growing rapidly up to 20 percent annually as reported by (Irfan *et al*., 2016) [33]. Now a day's maximum area covered under organic forming is reported in Asia up to 36 percent in the world following Africa and Europe up to 29 and 17 percent respectively (Kumar *et al*., 2017) [36]. Reason behind a sudden boost in organic forming is that the increased consumers preference towards organic food grains and vegetables to avoid the health hazards and environmental balance (Seufert *et al*., 2017) [25]. In developed and prosperous countries consumers consider the organic food products to be safe and health booster as they contains lower amount of pesticide residues (Fank and Kennedy, 2016; Michael and David Tilman, 2017) [24, 45]. Organic forming preserves and refills the nutrients in the soil by decomposing the plant debris and also control naturally the infestation of insect pests. Organic forming completely prohibits the use of chemical fertilizers, pesticides, insecticides, weedicides, growth regulators, sewage sludge and genetically modified Different agricultural practices such as green manuring, rotating crops and cover cropping results quality food grains production, improved micro-organism count and soil health. Organic cultivation of crops is done mainly by the use of legume green manure, farm yard manure, compost prepared from crop residues, Vermicompost, organic waste of animals and oil free cakes (Nenna and Ugwumba, 2014) [51]. Organic forming increase organic matter content in the soil results valuable changes in soil physical properties such as increased water holding capacity, porosity for proper gas exchange and reduced bulk density which reduce the risk of soil erosion (Mamaril *et al*., 2009; Irfan *et al*., 2016) [43, 33]. Organic forming also contributes to increase the biodiversity, strengthen the ecosystem and fully utilization of natural resources to enhance the crop yield. Organisms (GMOs) that also reduce the cost of cultivation (USDA, 2015) Fig-1. Organic food grains, vegetables, fibers and their value added products having high price in the market therefore, it strengthen the formers economy than those practicing conventional forming.

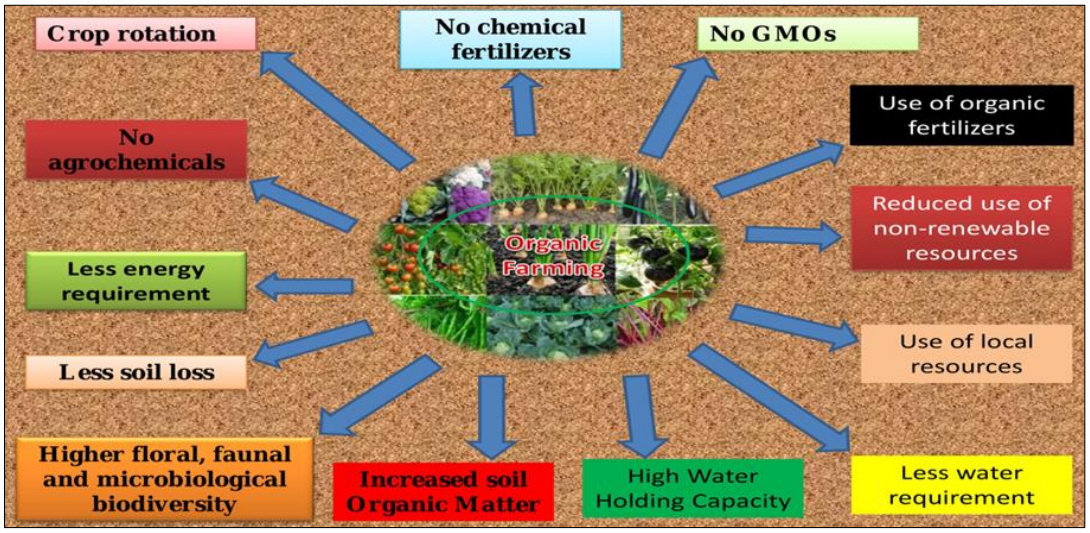

Fig 1: Basic principles and effects of organic farming

Sources of organic manures: Organic manures can be classified in to bulky organic manures and concentrated organic manures. Bulky organic manures are derived mainly from plants, animals and other organic wastes and also from green plants tissues. Further these can be well decomposed animal plant and other organic residues such as farm yard manure (FYM), Vermicompost, compost from farm and town residues, poultry manure, night soil, sewage and sludge, whereas undecomposed organic manure obtained from green plant tissues is also termed as green manure. For green manuring leguminous crops like sunhemp, dhaincha, mung, cowpea, guar, senji, khesari berseem and non-leguminous crops *viz*., bhang, jowar, maize and sunflower are grown for a specific period and then plowed and incorporated in the soil primarily to add nutrients and organic matter in the soil. Concentrated organic manures are organic in nature and contains higher percentage of major plant nutrients like N, P2O5 and K2O in comparison to bulky organic manures and are derived from oil free cakes such as mustard cake, soybean cake, blood meal, bone meal, meat meal, fish manure, horn and hoof meal, wool wastes and others (Timsina, J., 2018) [64]. Further these are non edible to cattle such as mahua, neem, castor, cotton, karanj, safflower, jatropha oil cakes and edible cakes are coconut, cotton and safflower seed cake (decorticated), mustard, groundnut, linseed cake, sesame cake and soybean oil free cakes etc.

Table 1: Average nutrient content of organic manures

Manure	Content (%)		
	N	P_2O_5	K_2O
Animal refuse	0.3-0.4	0.1-0.2	0.1-0.3
Cattle dung, fresh	0.4-0.5	0.3-0.4	0.3-0.4
Horse dung, fresh	0.5-0.5	0.4-0.6	0.3-1.0
Poultry manure, fresh	1.0-1.8	1.4-1.8	0.8-0.9
Sewage sludge, dry	2.0-3.5	1.0-5.0	0.2-0.5
Cattle urine	0.9-1.2	trace	0.5-1.0
Horse urine	1.2-1.5	trace	1.3-1.5
Human urine	0.6-1.0	0.1-0.2	0.2-0.3
Sheep urine	1.5-1.7	trace	1.8-2.0
Ash, household	0.5-1.9	1.6-4.2	2.3-12.0
Rural compost, dry	0.5-1.0	0.4-0.8	0.8-1.2
Urban compost, dry	0.7-2.0	0.9-3.0	1.0-2.0
Farmyard manure	0.4-1.5	0.3-0.9	0.3-1.9
Rice hull	0.3-0.5	0.2-0.5	0.3-0.5
Groundnut husks	1.6-1.8	0.3-0.5	1.1-1.7
Bone meal			
Raw bone meal	3.0-4.0	20.0-25.0	trace
Steamed bone meal	1.0-2.0	25.0-30.0	trace
Fish meal	4.0-10.0	3.9	0.3-1.5
Non edible oil cakes			
Castor cake	4.3	1.8	1.3
Cotton cake	3.9	1.8	1.6
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.8
Neem cake	5.2	1.0	1.4
Safflower cake	4.9	1.4	1.2
Edible oil cakes			
Coconut cake	3.0	1.9	1.8
Groundnut cake	3.0	1.9	1.8

Rape seed cake	5.2	1.8	1.2
Sesame cake	6.2	2.0	1.2
Niger cake	4.7	1.8	1.3
Nutrient content of important green manure crops			
Crop	**Nutrient content % (on dry weight basis)**		
	N	**P**	**K**
Sesbania aculeate	3.3	0.7	1.3
Crotalaria juncea	2.6	0.6	2.0
Sesbania speciosa	2.7	0.5	2.2
Tephrosia purpurea	2.4	0.3	0.8
Phaseolus trilobus	2.1	0.5	-

Source: "Hand book of Manures and Fertilizers" 1964 [30], and Dhama A. K. (1996) [21]

Present study of organic agriculture on crop productivity:
Organic agriculture can feed the world and fulfill the future need is a matter of great controversy. Meta- analysis conducted by Ponisio *et al*., (2015) [53], Seufert *et al.,* (2012) [59] and de Ponti *et al.,* (2012) [12] on 1071 paired yield samples in 115 studies reported 19.2% reduced yield in organically managed field than conventionally managed. USDA, 2018 [68] made 292 comparisons for yield gap among different crop groups and find lower organic yield (i.e., 84% on area basis). However, 55 comparisons were reported with higher organic yield and 89 percent organic yielding crops were hay and silage crops than food crops. Although it is well established fact that organic yield gap is predominant in fruit and vegetable crops that can vary with crop group and geography. Organic matter addition in soil to improve crop yield is a traditionally well known practice. Improvement in crop yield after application of organic manure has been reported by many researchers. FYM improved the yield and quality of wheat reported by (Holic *et al*., 2018 and Kavinder *et al*., 2019) [32, 34]. In radish recorded the root weight, shoot weight and biological yield significantly higher by application of poultry manure, bone meal and PSB culture (Sahu *et al*., 2018) [57]. Fresh weight of radish was found highest by applying poultry manure and vermin-compost (Gyewali *et al*., 2020; Basnet *et al*., 2021) [29, 12]. In 2017, 1.1% organic vegetable production was recorded of the total vegetable production by Willer and Lernoud, (2019) [71]. Beneficial effects of organic manures like poultry manure, vermin-compost on growth, crop yield and quality parameters in radish were also reported by (Singh *et al*., 2016) [62]. In maize, FYM application increased grain yield and number of grains per cob (Khan *et al*., 2017) [35] and application of poultry manure 30 t/ha increased grains/cob and grain yield (Enujeke, 2013) [23], whereas, in wheat and rice FYM doses 16t/ha, 30t/ha and 72t/ha increased the yield up to 17%, 72% and 140% respectively (Chandra *et al*., 2021). In low land rice 16% increased yield obtained by application of FYM (Asai *et al*., 2021) [7]. In onion application of FYM and inorganic nitrogen gave highest marketable bulb yield of onion (Gererufae *et al*., 2020) [27]. Vermin-compost, FYM, poultry manure and neem cake application in chilli increased number of fruits, fresh fruit weight, in which poultry manure reported better than the rest (Soreng and Kerketta, 2017) [63]. Application of vermin-compost 5 t/ha led to the maximum growth, yield and quality of garlic crop (Alemu-Degwale, 2016) [5]. In tomato, number of fruits per plant, fruit weight, fruit yield per plant and per square meter increased with FYM, VC and waste decomposer application (Rajya *et al*., 2015 and Meena *et al*., 2021) [55, 44]. In okra, poultry manure produced 200 qt./ha yield was superior following vermicompost, goat manure, sesame cake and mustard cake over control (Bhandari *et al*., 2019) [15].

Impact on quality parameters of crops

Table 2: Effect of Organic manures alone or in combination with Fertilizers on Quality Parameters of Crops

Wheat	FYM + N_3PK	High crude protein (13.21%) and wet gluten content (30.17)	Holic *et al*., 2018 [32]
Radish	FYM + PM + PSB + Bone meal	High vitamin C content (2.87 mg/ml) and TSS (2.20 ^{0}Brix)	Gyewali *et al*., 2020 [29]
Cauliflower	PM	Enhanced vitamin C content (11.75 mg/100g) in comparison to NPK (10.86 mg/100g)	Mishra *et al*., 2018 [46]
	VC Mustard oil cake	-Vitamin C content (10.92 mg/100g) -Vitamin C content (10.60 mg/100g)	Basnet *et al*., 2017 [13]
	VC	-Vitamin C content (33.09 mg/100g);	Acharya *et al*., 2020 [1]
Garlic	VC	Marketable yield of garlic increased up to 9.96% and TSS from 5.13 to 5.69% (^{0}Brix)	Alemu-Degwale, 2016 [5]
Tomato	Fully organic management	Maximum ascorbic acid content (18.43 mg/100g)	Rajawat *et al*., 2019 [54]
	RDF + FYM	TSS up to (5.0 ^{0}Brix)	Rajya *et al*., (2015) [15]
	RDF + VC	Juiciness, titrable acidity, shelf life up to 11.67 days and ascorbic acid content (26.54 mg/100g)	
Cabbage	PM + Azotobactor	Maximum vitamin C content in cabbage (44.05 mg/100g)	Arshpreet Kaur, 2020 [6]
Okra	FYM + VC + PM + Neem oil cake + Sea weed extract	High ascorbic acid content (15.26 mg/100g)	Mishra *et al*., 2019 [47]
Coriander	VC	Increased carotenoids (2.25 mg.fr.wt) and protein (23.32 mg.fr.wt) than control	Ravimycin *et al*., 2016 [56]
Broccoli	RDF + VC	Maximum vitamin C (103.97 mg/100g)	Singh *et al*., 2018 [61]
Cotton	FYM	Maximum fibre staple length (26.95 mm) and fibre strength (27.60 g tex^{-1})	Kumar *et al*., 2017 [36]
	Neem cake	Highest fibre strength (28.10 g tex^{-1})	
Chickpea	VC	Highest protein content (20.83%)	Kushwaha *et al*., 2021 [16]
Baby Corn	FYM + VC	Maximum enhancement in protein (35.6%) and ascorbic acid (22.7%)	Babu *et al*., 2020 [9]

Soybean	75% NPK + 25%, VC + Rhizobium + PSB	Produced oil content (20.1%) and protein content (41.5%)	Verma *et al*., 2017 [69]
Chilli	VC + vegetable waste	Protein content higher at 60 DAS (113 mg/g) and 90 DAS (79 mg/g)	Yadav and Vijayakumari, 2004 [72]
Rice	FYM	Hulling and milling percentage, protein and amylase content	Dixit and Gupta, 2000 [22]

Impact on soil physical, chemical and biological properties

Soil fertility management is crucial for sustainable agriculture and land use. Biological activities found greater in organically managed soils than conventionally managed soils. Organic fields have greater soil stability. Addition of organic manure in the soil increase soil microorganism activity and biomass, soil respiration, soil enzymes activity and plant nutrient availability.

Table 3: Effect of Organic manures on soil properties

PM + BC	MC, porosity, reduced bulk density and high content of Ca and Mg in soil	Adekiya *et al*., 2020; Mukherjee, R., 2013 [3, 49]
BC	Increases content of soil moisture, available K and P	Pandit *et al*., 2018 [52]
BC, PM	Increased soil pH, OC, N, K, Ca, and Mg. improved physical properties *viz*., reduced bulk density, soil porosity, water content, aggregate stability, penetration resistance and dispersion ratio	Agbede, 2021 [4]
Rice husk BC + organic manure	In clay soil reduced bulk density (23.1%), increased soil organic matter (135.3%), porosity (45.6%), sand fraction (81.5%), macropore (40.1%), micropore (60.9%) and moisture content in the field capacity (30%)	Widowati *et al*., 2020 [70]
Corn cob BC + organic manure	In sandy soil decreased saturated hydraulic conductivity (59.3%), macropores (67.4%) and increased organic matter (16.5%), porosity (16.9%) and micropores (60.2%)	Widowati *et al*., 2020 [70]
Pressmud, FYM, CM	Improved moisture content, organic matter, saturation percentage, reduction in pH, increased water retention and availability of macro and micronutrients to plants	Ashraf *et al*., 2021 [8]
PM + LM	Increased microbial biomass, C and N content (+89%, +74%), respiration rate (+49%) and soil microbial quotient (+45%)	Li *et al*., 2011 [38]
VC @ 12 t/ha and Compost @ 12 t/ha	Increased OC (1.3%), available content of N (138 mg/kg), P (15.45 mg/kg), K (79.85 mg/kg), S (28.50 mg/kg), Ca (2043 mg/kg) and Mg (335.3 mg/kg); similarly Na (41.8 mg/kg), Fe (60.2 mg/kg), Mn (26.3 mg/kg) and Zn (2.20 mg/kg).	Nasrin *et al*., 2019 [50]
BC + PM	Increased P concentration, enzymatic activities and WUE	Lima *et al*., 2021 [39]
BF and OF	Enhanced soil fertility by increasing OM (55-57%), N (25-36%), P (116-123%) and K (99-100%) after four season fertilization	Lin *et al*., 2020 [40]
CD	Organic carbon was found 14.44% higher	Roy and Kashem, 2014 [58]
CM	Application increased OC - 16.82%	
CD + CM	Increased OC content - 12.85%	
CD + CM	Increased Nitrogen content (16.36%) and EC (81.59%) after 60 days of incubation over the control	

PM= poultry manure, BC= Biochar, MC= Moisture content, OC= Organic carbon, FYM= Farm yard manure, CM= Chicken manure, LM= Livestock manure, VC= Vermicompost, BF= Biofertilizer, OF= Organic fertilizer, CD= Cow dung, EC= Electrical conductivity.

Impact on environment

Organic agriculture influences environment and existing biodiversity directly through limiting the use of agrochemicals and inorganic fertilizers whereas, indirectly by changing the cropping system, crop rotation and using organic manures. Increased biodiversity on the organic forms up to 30% more has been reported by (Tuck *et al*., 2014; Hardman *et al*., 2016) [65, 31]. Fully organically managed farms displayed higher species richness, 30-34%, organism's abundance up to 50% and higher species evenness than conventionally managed farms (Bengtsson *et al*., 2005; Tuck *et al*., 2014; Crowder *et al*., 2010) [14, 65, 19]. Organic farms use less energy 10-70% and lower greenhouse gases emission up to 39%, nitrous oxide up to 14-31% than conventional farms per unit land (Gomiero *et al*., 2008; Mondelaers *et al*., 2009; Tuomisto *et al*., 2012) [28, 48, 66]. Reduction in nutrient leaching is also reported in organic farms *viz*., nitrate 30-31%, ammonia 18% and also phosphorous lower than conventional farms (Mondelaers *et al*., 2009; Tuomisto *et al*., 2012) [48, 66]. High soil organic matter 6-7%, more soil microorganisms and their activity is reported by (Tuomisto *et al*., 2012 and Lori *et al*., 2017) [66, 42] in organic farms.

Impact on community health

Demand of organic food products in consumers increasing day by day due to negative impact of conventionally produced food by the use of agrochemicals and fertilizers causing various health problems and environmental disturbance. As for consumers concern, organically produced food is more safe and healthier than produced by the use of chemicals and fertilizers (Funk and Kennedy, 2016) [24]. Organically produced food has higher concentration of antioxidants and lower pesticide residues and cadmium (Cd) reported by (Baranski *et al*., 2014) [10]. Prohibited use of agrochemicals such as insecticides, pesticides, herbicides and chemical fertilizers in organic agriculture reduce the risk of health hazards from water pollution, soil pollution, and air pollution associated with soil erosion, emission of particulate matter and oxides of N, C and S (Lorenz and Lal, 2016) [41].

Future Prospects

1. Organic forming will boost economy of marginal formers
2. Will make cast effective agriculture
3. Long term sustainability of agriculture
4. Will reduce dependence on harmful agro-chemicals and fertilizers
5. Improve soil health by adding organic nutrients
6. Will contribute in preservation of biodiversity
7. Will minimize the soil, water and air pollution
8. Will be helpful in low water consumption
9. Will maximize the use of renewable energy resources
10. Will fulfill the demand of organic food products in the market
11. Organic agriculture will be helpful in maintaining

ecological balance
12. Will creates jobs in agriculture, food processing and marketing sector.

Conclusion

Our above analysis conclude that organic forming could be a better option to maintain the ecological balance of nature and natural resources without harming its components. Recycling of agricultural, animal waste and nutrients maintain ecological balance and also increase biodiversity. Improved water holding capacity by organic manure application check soil erosion and prohibit use of chemical fertilizers, pesticides, insecticides and herbicides reduce soil water and air pollution. Use of organic manures not only improve the quality and yield of crop produce but also sustain soil health and productivity. Organically produced food products are highly safe and healthy having very less or no contamination of residues of agrochemicals and fertilizers. Moreover, organically grown vegetables and food grains having high demand and price in the market improves economy of the farmers.

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