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Review Article

Review on the Effects of Organic Farming on Soil Fertility and Crop Production in Ethiopia

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ABSTRACT

The review summarizes the literature on the effect of organic farming on soil fertility and crop production. Most of investigators confirmed that organic farming application could improve the physical, chemical and biological characteristics, soil organic matter, and nutrient status of the soils. Organic farming is long term and sustainable way of improving soil fertility and crop productivity. Organic systems use a strategically different approach, which relies on longer-term solutions (preventative rather than reactive) at the systems level. In addition, due to its multiple positive effects on the physical, chemical and biological soil properties, contributes to the stabilization and increase of crop productivity and crop quality. Consequently, most investigators proved that organic farming has an equalizing effect of annual/seasonal fluctuations regarding water, air and heat balance of soils, the availability of plant nutrients and thus the final crop yields. Thus, for sustainable agricultural systems within small scale farming in developing countries like Ethiopia, organic farming can be a good option for developing effective plant nutrient management strategies in many situations.

Keywords: Organic farming; Soil fertility; Crop productivity; Minerals; Microbes

INTRODUCTION

Soil fertility is fundamental in determining the productivity of all farming systems. Soil fertility is most commonly defined in terms of the ability of a soil to supply nutrients to crops. Swift, et al. however suggest that it is more helpful to view soil fertility as an ecosystem concept integrating the diverse soil functions, including nutrient supply, which promote plant production. This broader definition is appropriate to organic farming, as organic farming recognizes the complex relationships that exist between different system components and that the sustainability of the system is dependent upon the functioning of a whole integrated and inter-related system [1-5].

Organic farming could be an option to ensure food, air, water, and soil quality leaving the environment safe for the present and future generation. Long term field experiments have made clear the negative impact of continuous use of chemical fertilizers on soil health.

Organic farming systems rely on the management of soil organic matter to enhance the chemical, biological, and physical properties of the soil, in order to optimize crop production [6]. Soil management controls the supply of nutrients to crops, and subsequently to livestock and humans. Furthermore soil processes play a key role in suppressing weeds, pests and diseases. One of the fundamental differences between management of organic and conventional systems is the way in which problems are addressed. Conventional agriculture often relies on targeted short-term solutions e.g. application of a soluble fertilizer or herbicide [7]. Organic systems, in contrast, use a strategically different approach, which relies on longer term solutions (preventative rather than reactive) at the systems level. An example of this is the importance of rotation design for nutrient cycling and conservation and weed, pest and disease control.

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Lampkin, et al. organic farming is a production system which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and livestock feed additives [8].

Koferi, et al. (Korean organic farming environment research institute) it is the farming method by which we never use compound chemical fertilizers, agricultural chemicals, pesticides, growth hormones and uses natural sources such as organic matters, minerals, and microbes [9].

According to national organic standards board of the U.S. defines organic farming as an ecological production management system that promotes and enhances bio diversity, biological cycles and soil biological activity. Organic farming refers to organically grown crops which are not exposed to any chemicals right from the stage of seed treatments to the final post-harvest handling and processing.

Organic farming relies on crop rotation, crop residues, animal manures, legumes, green manures, off-farming organic wastes, agricultural cultivation, mineral bearing rocks and aspect of biological pest control to maintain soil productivity and tilth to supply plant nutrients and also to control insects, weeds and other pests [10].

The objective this paper

Hence, in this review paper, we have reviewed the literature to explain the role of organic farming on soil fertility and crop production [11].

LITERATURE REVIEW

Concepts and definition of organic farming on soil fertility

Soil fertility is fundamental in determining the productivity of all farming systems Watson, et al. and thus inseparable from food security. Soil fertility is often defined as the soil's ability to supply nutrients to crops but it can be defined more widely as an ecosystem concept Swift, et al. which integrates the diverse functions of soil that promote plant growth, including nutrient supply [12]. This broad definition is fitting as organic farming recognizes the complexity of relationships between different components of any farming system and that sustainability depends on the functioning of the whole integrated system [13]. A basic concept of organic farming is that "the health of soil, plant, animal and man is one and indivisible" Balfour, et al.

Organic farming systems rely on the management of soil organic matter to enhance the chemical, biological, and physical properties of soil, in order to optimize crop production and health (Figure 1). Thus, the supply of nutrients to crops, and subsequently to livestock and humans, is the net result of a set of management decisions including rotation design, manure management, etc., as well as soil management peruse. The central concept of soil fertility in these systems is the use of legume-based multi-annual rotations together with the careful use of on-farm manures Stockdale, et al.

Figure 1: Components of organic farming.

Organic farming such as the inclusion of grass leys have regularly been shown to increase the organic matter content of soils clement, et al. However, the impact across the whole rotation will depend, amongst other things, on the balance between annual and perennial crops and tillage intensity [14]. Maintaining ground cover throughout the year by using green manures and/or cover crops is another recommended practice which has a number of environmental benefits including protection of soil organic matter, soil structure and water quality [15-18]. Management of manures and other organic wastes can also have differential effects on soil organic matter and soil biodiversity, with properly composted manures as recommended in organic farming having a more beneficial effect than fresh manures. Organic farming systems are generally associated with increased soil biological activity and increased below ground biodiversity [19].

The four IFOAM main principles of organic production

The principle of health: Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

The principle of ecology: Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

The principle of fairness: Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

The principle of care: Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment [20].

Effect of organic farming on the soil media and nutrient content

Farmyard manure, vermicomposting and compost to make crop cultivation sustainable. Organic farming is not mere non-chemical agriculture, but it is a system integrating relations between soil, plant and water. Organic farming helps in soil health, proper energy flow in soil, crop, water environment

systems, keeps biological life cycle alive and helps in sustaining considerable levels in yield.

It is mainly based on principles of restoration of soil organic matter in the form of humus, increasing microbial population, skillful application of the factors contributing soil life and health and treating manures in bio-dynamic way Pathank RK, et al.

Application of organics matter which is an important component in organic farming, apart from improving the soil physical, chemical and biological properties with direct impact on moisture retention, root growth and nutrient conservation, can also reduce the cost of production in agriculture. Keeping these benefits points in view an investigation was carried out to find out the plant nutrients supplied through organic sources had profound effect on growth and productivity of the crop either by acceleration of respiratory process with increasing cell permeability and hormonal growth action or by combination of all these processes. Through their biological decomposition processes the organic sources supply nutrients to the plants in the available form. They are also rich in micro nutrients besides having plant growth promoting substances *viz.*, hormones, enzymes and humus forming beneficial microbes. Organic sources, on application to the soil, improve the physical properties of soil such as aggregation, aeration, permeability and water holding capacity Mukesh K, et al. which promote growth and development of plants. It has been reported that among the organic sources of nutrients, poultry manure proved to be the Razzaq Owayez, et al. best source of organic manure which helped in improving physico-chemical properties (pH, EC, organic carbon, macro and micro nutrients) of soil because of its higher analytical values Govindarajan K, et al.

Crop and soil management: Organic farming systems encourage the use of rotations and manures to maintain soil fertility. Crop rotations with legumes add to soil fertility. Green manuring and intercropping of legumes is another important aspect for organic farming system not only in regard to weed control, but also in reducing the leaching of nutrients and in reducing soil erosion. Carefully managed soils with high proportion of humus offer essential advantages with respect to water retention, ion exchange, soil erosion and animal life in the soil.

A high proportion of humus in the soil gives uniform distribution of nutrients and also plant hygiene. Crop rotations and crop mixtures are designed with a strong awareness of their impact on soil structure. Soil compaction has serious consequences for yield which organic farmers cannot afford. crops and varieties with different rooting depths, rates of root extension, lifespan and architecture can be used to maintain carbon inputs to different parts of the soil profile Ball, et al. but also to help with maintaining soil structure and water retention capacity. Lower rates of run-off and soil erosion have been measured in organic systems Reganold, et al. and there is a suggestion that improved water holding capacity in organic systems may support greater yield stability in drought years.

Features of organic farming such as lower stocking rates can also help to prevent soil compaction and erosion, particularly in upland situations. Careful management of non-crop areas including hedgerows and buffer strips can help prevent erosion and nutrient loss to water courses.

Crop rotation is a key tool for maximizing nitrogen retention within the system. Maintaining ground cover using cover crops, together with the appropriate timing of ploughing and manure applications can help minimize nitrogen loss from the arable part of a rotation. Leaching losses can be high on a single field following ploughing of leguminous leys but averaged over a whole farm or catchment these are moderated by lower losses from other parts of the rotation.

Compost for soil fertility: Compost use is one of the most important factors, which contribute to increased productivity and sustainable agriculture. Compost consists of the relatively stable decomposed organic materials resulting from the accelerated biological degradation of organic materials under controlled, aerobic conditions.

The application of compost generally influences soil structure in a beneficial way by lowering soil density due to the admixture of low density organic matter into the mineral soil fraction (Table 1). This positive effect has been detected in most cases and it is typically associated with an increase in porosity because of the interactions between organic and inorganic fractions.

Table 1: The effect of compost on soil property.

Treatment	Bulk density (gm/cm^3)	Organic matter (%)	Moisture content (%)	NO_3 (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
0 t/a (cont)	1.18	5.36	26.01	3.28	30.09	206.83	3416.17	171.4
30 t/a	1.01	5.64	25.86	4.96	52.34	744.97	3779.88	297.59
60 t/a	0.98	6.57	28.07	5.89	61.02	1053.36	4748.7	431.3
120 t/a	0.91	9.46	32.16	16.01	76.65	1418.7	5492.18	787.92

Green manures in soil fertility: Green manuring is the process of raising crops and intentionally incorporating them in the soil at vegetative green stage or flowering stage. Green manuring is natural farming. Green manuring helps to improve the physical and chemical properties of the soil. Green manuring is method of substituting a basket of compost with handful of seeds.

Green manures, as the name implies, are used primarily for the addition of nutrients and organic matter to the soil, protecting and improving soil quality. Green manure crops are typically

grown for a specified period during a rotation when a field is not in use, and are then plowed under and incorporated into the soil before the succeeding crop is established. Green manures, generally legumes contribute higher amount of nitrogen. They fix atmospheric di-nitrogen by symbiosis with rhizobia (rhizobium, bradyrhizobium, sinorhizobium and mesorhizobium). The legume rhizobium symbiosis compensates 40 percent of worlds fixed nitrogen.

Vermi compost for soil fertility: Vermicomposting process significantly changed the physico-chemical properties of different waste mixtures. The vermicomposting was much darker in color, had good esthetics and processed into a homogeneous mixture after earthworm activity. The total amount of waste mixture was reduced 1.4-2.5 times after vermicomposting. This clearly indicated that the vermicomposting process significantly helps in abatement of organic matter pollution load in the environment. Electrical Conductivity (EC) of vermicomposting was higher than soil, which may be due to the presence of more salts in the feed of cattle. The micronutrients content was significantly higher in vermicomposts than soil but was within permissible limits as recommended by European and American limits of micronutrients in the compost. Vermicomposting is an excellent soil conditioning agent. Incorporation of vermicomposting in soil improves the texture, structure, permeability and water holding capacity of soil.

Bio fertilizer on soil fertility: A bio-fertilizer is a substance which contains living microorganisms which applied to seeds, plants, or soil, colonizes the rhizosphere or the interior of the plants and promotes plant growth by increasing the supply of nutrients to the host plant Bardi, et al.; Malusa, et al. Bio-fertilizers are widely used to accelerate those microbial processes which augment the availability of nutrients that can be easily assimilated by the plants. They improve soil fertility by fixing the atmospheric nitrogen and solubilizing insoluble phosphates and produce plant growth promoting substances in the soil. These bio fertilizers have been promoted to harvest the naturally available biological system of nutrient mobilization which enormously increases soil fertility and ultimately, crop yield.

At present times, there is a growing concern about environmental hazards and threats to sustainable agriculture. In view of the above stated facts, the long term use of bio-fertilizers proves to be economical, eco-friendly, more efficient, productive and accessible to marginal and small farmers over chemical fertilizers.

Managing crop residues: Crop residues can be an important source of nutrients to subsequent crops. It is well documented that different quantities of N, P, K and minor nutrients are removed from, and returned to, the soil depending on the crop species concerned Wild, et al.; Sylvester-Bradley, et al. The quantity and quality of crop residues will clearly influence the buildup of soil organic matter Jenkinson, et al. and the subsequent availability and timing of release of nutrients to following crops Jarvis, et al. Residues also contain variable amounts of lignin and polyphenols, which influence decomposition and mineralization rates. Incorporation of N rich, low C: N ratio residues leads to rapid mineralization and a large rise in soil mineral N Rahn, et al. while residues low in N such as cereal straw can lead to net immobilization of N in the short to medium term Jenkinson, et al.; Aulakh, et al.

DISCUSSION

Organic farming on crop production

The foundation of organic agriculture lies in the health of soil. Soil fertility management maintains and improves soil condition and minimizes erosion. Strategies used to achieve this include crop rotation, the use of green manures and cover crops, the application of plant and animal matter and the application of allowable soil amendments. Nutrient levels in soil should be regularly tested to determine the amount of nutrients required for optimum growth of a particular crop as well as the necessary amount of manure, compost and allowable fertilizer that should be applied.

Conventional agriculture frequently relies on targeted short-term solutions to solve nutritional problems e.g. application of a soluble fertilizer. In contrast, organic systems use a strategically different approach, which relies on longer-term solutions (preventative rather than reactive) at the systems level. An example of this is the importance of rotation design for nutrient cycling and conservation as well as weed, pest and disease control Stockdale, et al. Yields of arable crops under organic management vary from as little as 50% to more than 95% of those in conventional agriculture (Lampkin and Measures 2001, SAC 2002). In relative terms, spring cereals perform better than winter cereals in organic systems. Shekara, et al. reported increase in growth, yield attributes and yield of rice due to addition of various organic manures, which could be attributed to adequate supply, higher uptake and recovery of nutrients. According to Kashyap, et al. the maximum grain (58.12 q ha^{-1}) and the straw (59.79 q ha^{-1}) yields were obtained due to application of 50% RDF through NPK+50% N through farm yard manure. The combined application of FYM@ 10 t ha^{-1}+Vermicomposting@ 1.25 t ha^{-1} resulted in maximum yield of wheat.

CONCLUSION

Organic farming systems can deliver agronomic and environmental benefits both through structural changes and tactical management of farming systems.

The benefits of organic farming are relevant both to developed nations (environmental protection, biodiversity enhancement, reduced energy use and CO_2 emission) and to developing countries like Ethiopia (sustainable resource use, increased crop yields without over-reliance on costly external inputs, environment and biodiversity protection, etc.). Organic farming systems rely on the management of soil organic matter to enhance the chemical, biological, and physical properties of soil, in order to optimize crop production and health.

Generally we organized this review from different scholar finding and we recommended that farmers use organic farming system is better to improve soil fertility and crop productivity than conventional agriculture in sustainable manner.

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