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Impact of Organic Farming on soil fertility and crop productivity

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Abstract

The rising in population and demand in different agricultural commodities becomes an important challenge in the field of agriculture. Maintaining crop production and soil health is an important upcoming major challenge in agriculture. Due to the unsupervised use of synthetic means of farming i.e. inorganic fertilizers, pesticides, herbicides, etc. human and environmental health is being seriously affected. There is a serious decline in the soil fertility which in turn is affecting the yield of the crops. Excessive and unsupervised usage of pesticides results in pest gradually getting immune to the pesticides. So organic farming is the only proper alternative to synthetic fertilizers for sustainable agriculture. It is strongly believed that increase crop production and boosting the soil quality and long-term manipulation of soil properties can be achieved by organic farming. This is due to the reason that upon decomposition, organic matter releases macro and micronutrients into the soil solution that becomes accessible to plants throughout the crop period, contributing to higher nutrient uptake and improving the soil properties. The term sustainability is acquiring popularity among various entities and it is gaining popularity in agriculture. Although the Green revolution or third agriculture revolution increased the production and fulfilled the aspiration by changing India from food-importing to exporting nation, but now it is being criticized for its high energy and input use. Unsupervised use of different chemical leads to the toxicity of the consumable products and the quality of soil and environment is seriously affected. In conventional agriculture, the agriculture system is forced to produce more and the regenerative capacity of the natural resources decreases and this affects productivity in the long term. Organic is a significant substitute for conventional farming to reduce the ill-effects of chemical agriculture. For low-input agriculture, organic farming's crop productivity is equivalent to conventional farming. Many studies have reported that organically produced agricultural products are better than as compared to products produced by conventional methods.

Introduction

Organic farming is simple and traditional farming that has been practised by our ancestors, where only natural and farm products are used as input. It is being practised in around 150 countries worldwide and is gaining gradual momentum across the globe. This is due to the reason that now different consumers have become conscious about the ill-effects of chemicals used in conventional farming and on the other hand high

premium healthy products produced through organic farming methods are gaining their popularity. Organic products are labour-intensive and are difficult to manage than conventional farming. However, organic foods have a higher cost than conventional farming to procure the income of the farmers. The farmers can be well paid for organic crops for their high demands on domestic, regional, and international markets (Kalyan, 2005).

Organic agriculture integrates cultural, biological and chemical practices. It harnesses the benefit of natural resources, flora, and fauna and provides a favourable environment for them. It is diverse and includes all the possible organisms complementary in the system. Organic agriculture includes different techniques and nutrient management and an important factor that determines the yield. Due to excessive use of chemicals, there is a serious decline in the soil fertility which in turn is affecting the yield of the crops. It is strongly believed that long-term manipulation of soil properties by organic farming can maintain and increase crop production and enhance the soil properties. This is due to the reason that upon decomposition, organic matter releases macro- and micronutrients into the soil solution that becomes accessible to plants throughout the crop period, contributing to higher nutrient uptake. According to Shashidhara, 2000, the organic inputs applied in organic farming are readily available, releases nutrients gradually, supply macro and micronutrients and contribute favourable soil environment for the micro-organisms. Maintaining crop production and soil health at the same time becomes an important upcoming major challenge in agriculture.

Organic sources of plant nutrients

Organic sources of nutrients have less concentration of nutrients and release them slowly as compared to chemical fertilizers. The crop is adversely affected when it is deficient in the nutrients ultimately affecting its growth and development. Fruitful organic farming in any crop can be achieved by the application of the right nutrient source, in the right amount and at the right time. Since insufficiency of nutrients at any stages of the crop can adversely affect the crop production. Therefore careful nutrient management is important for successful crop production in organic agriculture. C:N ratio is a crucial component that determines the efficacy of organic nutrients. If the C:N ratio is higher it will slow down the release of nutrients and in some cases immobilization takes place. Whereas when the C:N ratio decreases it will ensure the release of nutrients and improves the decomposition processes.

The availability of primary nutrients like NPK depends on the nutrient composition of the organic sources. However, the efficiency of organic nutrients is less as compared to mineral fertilizers but integrating organic and inorganic nutrient sources is found to be very effective to reduce environmental pollution along with increasing crop productivity and soil health for the long term. In addition to providing N, P, and K, organic fertilizers often make the scarce elemental N available, solubilizes phosphates, micronutrients, and helps in the decomposition of crop residues to promote the absorption of nutrients by plants. Organic sources of nutrients promote the activity of beneficial micro-organisms and increases growth, reduce deficiency of micronutrients therefore ultimately improves crop productivity and soil health (Nambiar *et al.,* 1992).

Vermicompost and farmyard manure (FYM) is commonly used as organic manures. According to Tandon (1992), well-rotted FYM had an average of 0.5% N, 0.2% P_2O_5, and 0.5% K_2O. A well-rotted FYM, when applied at 25 t ha^{-1}, could add 112 kg N, 55 kg P_2O_5, and 113 kg K_2O ha^{-1}, Gaur (1992). According to Pal 2002, the NPK content of vermicompost is 0.77 % N, 0.9% P_2O_5 and 0.45% K_2O. Farmyard manure is a decomposed organic matter produced from the activity of the microbial population in a warm and humid aerobic atmosphere using cow dung, cow urine and other waste materials available from cattle in the backyard (Ramprasad *et al.,* 2009). Farmyard manure is a rich source of nutrients with an intrinsic capacity to boost soil health and aeration, ability to retain water and substratum for the beneficial microbial community.

Decomposition of farmyard manure by microorganism results in the release of nutrients such as nitrogen, phosphorus, potassium and micronutrients from carbon dioxide, water and mineral plants.Combining the use of FYM and vermicompost along with concentrated manures like castor or neem cake results in higher N release, more nutrients and increase the nitrogen (N). Multiple researchers have reported that the incorporation of FYM increases the productivity of crop, improves the soil properties and reduces costs of production. Many researchers have also claimed that earthworm activity is higher in an organic field in contrast to the inorganically managed field (Edwards and Lofty, 1974).

Application of compost with liquid manure by top dressing is found very effective in maize than other practices of combining manures and mineral fertilizers. It was also reported that the maize grain yields were 11-17% higher than conventional grain yields (Onduruet *al.*, 2002). Kalyan, 2003 demonstrated that integrated use of rice straw compost with Azotobacter and PSB has a better result than using rice straw alone.

It is commonly known that bananas are heavy nutrient feeders. After harvesting of banana, the remaining can serve as a good source of nutrients because they contain a tremendous quantity of essential plant nutrients, which is being wasted. Therefore by using such waste plant material, many profitable by-products like fibre, paper, fabrics, organic manure, etc. can be acquired. It has been reported that while separating fibres from the pseudostem of bananas, the liquid component which is known as sap, contains a large amount of essential macro and micronutrients as well as growth enhancers Salunkhe (2010) analyzed banana pseudostem samples for their elemental composition and found that banana pseudostem contained macroelements ranging from 1.00 to 1.12% N, 0.50 to 0.71% P, 2.39 to 20.2% K and micronutrients ranging from 259 to 323.2 mg/kg Fe, 47.3 to 241.3 mg/kg Mn, 10.1 to 107.4 mg/kg Zn and 13.4 to 83.6 mg/kg Cu.

Effect of organic fertilizers on yield and yield attributes

The liquid organic manures contain nutrients and small quantities of growth boosters. It corresponds to the fundamental factor that revitalizes the growth cycle by reducing the physical, chemical, and physiological imbalances (Natarajan, 2008). Application of soil, mine spoil, and coir pith vermicompost at the ratio of (1:1:1) and RDF as integrated approach enhances the height of the plant, yield and number of leaves in comparison to mine spoil integrated with RDF, (Thanunathan *et al.*,1997). Integrated use of 50% N through

vermicompost, 50% N and 100 % P and K through chemical fertilizers along with Azospirillum is found effective in increasing the bulb yield of onion. When Azotobacter is added to the various combinations a marked rise in plant height and no. of leaves is observed as compared to the treatments with organic manures alone (Jayathilake *et al.*,2002). It has also been observed that spraying of biofertilizer + cow urine increases pods/plant, test weight and yield of seed compared with biofertilizer control and spraying only (Abraham and Lal, 2003).

According to Somasundaram *et al.,* (2003) application of panchgavya at 3% improves yield in comparison to the sole application of RDF. According to Somasundaram *et al.,* (2003), panchgavya application at 3 % increases yield compared to RDF's single-use. It was recorded that higher plant height, no.of leaves, leaf area, flowers per plant and flower weight were observed compared to cow dung extract, cow urine and vermicast extractwhen vermi-wash was used as a spray (Shivsubramanian and Ganeshkumar, 2004). This indicates a major increase in the panchgavya spray on yield components @ 3 per cent (Yadav and Christopher, 2006). Vermicompost, when applied with vermi-wash at 1:1, improves yield and plant height of chilli (George *et al.*, 2007).

According to Somasundaram *et al.,* (2007) soil treatment with bio-gas slurry from 3 milk animals with 3 per cent panchagavya foliar spray showed significantly higher maize, sunflower, green gram yields. In a similar study, it was reported that application of bokashi @ 750 kg/ha resulted in the highest number of fruits per plant and yield per brinjal plant while in tomato the maximum number of fruits per plant and yield per plant was found by the application of Bokashi @ 1250 kg/ha. Panchagavya was therefore highly effective and less costly with higher CBR followed by Amritpani and bokashi (Mohan and Srinivasan, 2008). Panchagavya foliar spray @ 3 per cent in mixture with any organic source improved the growth and yield of Kalmegh (*Andrographis panculata*) as opposed to the single-use of organic sources (Sanjutha *et al.*, 2008). However, in the application of FYM+NPK+ Panchagavya, a substantial increase in growth and yield parameter was observed in the treatment of 1% urea, or 2% DAP spray with vermin-wash spray (Kumar *et al.*, 2008). It was observed that in a rice potato cropping system, combining the use of neem cake, cow dung and compost along with N substantially increased organic carbon (OC) as compared to the sole use of inorganic fertilizers (Urkurkaret *et al.*, 2010). In a field experiment conducted with P solubilizers such as *Aspergillus awamori*, *Pseudomonas striata*, and *Bacillus polymyxa*, yields of various crops such as wheat, rice, and cowpea were significantly increased. Use of phosphate solubilizing microorganisms saved 30 Kg P_2O_5 ha-1 in the presence of rock phosphate (Afzal *et al.*, 2005;Yadav *et al.*, 2013)

The experimental finding of Jat and Ahlawat (2007) revealed that the treatment of 3 tons vermicompost ha^{-1} enhanced dry matter production, grain yield and protein content in chickpea. It also improved the uptake of nitrogen and phosphorus, increase the microbial count, Fodder yield of successively grown corn (*Zea mays* L.) compared to no application of vermicompost. Similarly, Sangakkara *et al.*, (2008) reported higher production of maize due to organic matter that improved water holding capacity of the soil

and enhanced root growth. Rice crops when organically produced have lower yield at the initial year but the productivity increases over time due to enhanced soil fertility. (Yadav *et al.,* 2013).

Application of compost with liquid manure by top dressing is found very effective in maize than other practices of combining manures and mineral fertilizers. In this case, the maize grain yields are 11-17% higher than conventional grain yields (Onduruet *et al.,* 2002). Kalyan, 2003 demonstrated that integrated use of rice straw compost with Azotobacter and PSB has a better result than using rice straw alone. Application of neem cake when combine with FYM is found very effective in the production of soybean crop than the sole application of FYM (Patil *et al.,* 2008). Azospirillum with PSB used as seed treatment with an application of vermicompost highest yield with better growth and quality is reported in sorghum, (Kagne *et al.,* 2008). In a field trial conducted in the effect of pseudostem sap in banana and vermi-wash in a mango tree, highest fruit retention was observed with the treatment of these two combinations in the ratio of 1:1 than the control plot. However, it was a norm with the application of enriched sap alone and sap and vermin-wash in a 2:1 ratio (Anon, 2011).

Effect of organic fertilizers on soil fertility

The agricultural soils are affected by certain man-made pressures by affecting the soil organic carbon (SOC), depletion of nutrients, soil compaction and heavy metal deposition (Smith *et al.,* 2016). High Soil Organic Carbon (SOC) plays a significant role in soil fertility. SOC enhances the soil structure, aeration, water-holding capacity, chemical buffering capacity, soil microbial activity, plant root development and also enhances the release of nutrients by the process of mineralization. In the research carried out by Gattinger *et al.,* (2012), it has been concluded that organic farms have higher Soil Organic Carbon than the conventional systems. It has been observed an increase in external carbon inputs, organic matter recycling and extended crop rotations with legumes of forage in organic agriculture. The Soil Organic Carbon Levels are raised by increasing yield which leads to an increase in the organic waste or a crop residue (Diacono and Montemurro, 2010). To minimize the depletion of soil nutrients and increase yield, the organic fertilizers in minimal or no external fertilizers can be increased (Watson *et al.,* 2002). Application of fertilizers with high nutrients, e.g. biogas digestate, or organic mineral fertilizers could give the potential increase in yield and production. However, they may not take part in increasing the levels or Soil Organic Carbon. Nutrient recycling with the food system can serve as the key means for long time sustainability of nutrients and are various promising options (Oelofse *et al.* 2013). Urban waste can be used for the production of compost in rural as well as urban areas. However, urban waste may contain toxic elements including heavy metals, e.g. Cd, which is a concern for public health (Åkesson *et al.,* 2014).

New recycling techniques like a source separation of sewage should be developed (Spångberg, 2014). Phosphorous can be obtained by crystallization and precipitation of sewage sludge or wastewater which will reduce the risk of contamination as compared to the untreated one. Treated wastewater sludge products might

have a higher contaminant content than fertilizers permitted under current organic regulations, including natural phosphate rocks and even animal wastes (Wollman and Möller,2015).

The use of urban waste products is limited and reduces the progress of organic agriculture than conventional ones. The use of a higher amount of concentrated manure in livestock diets to increase livestock yields may reduce the Soil Organic Carbon formation compared to ley (Freibauer *et al.,* 2004). It has been confirmed that with a crop rotation of clover/ grass ley there has been an increase in the organic carbon content in the dairy farms having annual crops mainly than the pig farms (Eriksson *et al.,* 2010). However, yield can be increased by increasing forage quality and optimizing ley harvesting time (Nadeau *et al.,* 2015). This promotes soil fertility and is beneficial than increasing the proportions of concentrates.

An integral component of organic matter includes 10-40% microbial population and humus (40-60 per cent). Organic matter has two fractions i.e. aboveground and belowground Above ground organic fraction constitutes animal residues and plant residues; belowground organic fraction constitutes micro-flora and living soil fauna. Organic matter improves soil structure, fertility, porosity, etc. It increases the microbial population to reduce soil erosion and maintains tilth. It acts as a depository of plant nutrients. Soil organic matter holds all of the essential plant nutrients necessary for their growth and development as they are acquired mostly from plant residues. The well balanced organic fraction (humus) adsorbs and holds nutrients in a plant-available form. According to Minhas and Sood (1994), soil organic matter after it's decomposition release macro and micronutrients and is made available to the plants throughout the crop duration, inducing in higher uptake of nutrients. Organic agriculture was efficient for sustainability, increase productivity, improving soil properties, increase soil micro-organisms and reduce pollution on a long-term basis. Clark *et al.*,(1998); Gaur *et al.*,(2002) observed that the use of organic nutrients in the production system increase the availability of the nutrients by increasing the organic carbon content, soluble and exchangeable P and K respectively. It maintains pH and maintained electrical conductivity (EC) level.

The use of compost increases the soil pH from 6.0 to 6.5 and reduces the weed infestation to a great extent from 29-78 per cent (Bullucket *et al.,* 2009). In the rice-wheat cropping system, deterioration of soil organic matter reduces nutrient supplying capacity, substantially on soils with a high organic content of soil (Yadav, 2000). Organic farming improves soil properties, level of organic matter and increases the uptake of nutrients (Subbiah and Kumaraswamy, 2000).

Effect of nutrients on chemical, biological and physical properties of soil

Organic fertilizers are also developed from microorganisms apart from animal and plant-based residue. Biofertilizers or microbial inoculants are ready-to-use live bacterial or fungal formulations when applied to plants, soil or composting pits, helps in the mobilization by their biological activity of various nutrients. Panchagavya, Jeevamrutha and Amritpani contain beneficial microorganisms and improves the yield and quality of the crop. The activities of microorganisms are enhanced by the application of jeevamrutha. Cowdung includes beneficial microorganisms such as nitrogen fixator (*Azotobacter* and *Azospirillum)* and

phosphorus solubilizing bacteria *Pseudomonas fluorescence* and potash solubilizing bacteria such as *Bacillus silicus* and are used in the preparation of Jeevamrutha (Ramprasad *et al.*, 2009).

Azotobacter improved seed germination, root growth and overall plant growth, Surekha (2007) showed that over an extended period, a steady enhance in grain yield was observed by organic fertilizers. Another relative study revealed that despite the higher inputs of organic rice production rice yields were only 55, 94, and 82 per cent of conventional rice production respectively. Nonetheless, lower yield costs with higher inputs are offset by higher prices of organic crops in the markets (Chan *et al.*, 2008).

Compost consist of different bacteria such as actinomycetes and fungi, humic material adds and stimulates the microbial population (Balasubramanian *et al.*, 1972). Compost plays a crucial role in the management of nematode and reduces the aftermath of pesticides through sorption. Sorption is a vital interaction between soil / organic matter and pesticides that reduce degradation and transport of pesticides in the soil. Pesticides that bind to the organic matter in the soil or clay particles become less mobile, however, they are bio-available but also become less achievable to microbial degradation are more tenacious (Gaur and S. K. Prasad, 1970; Prasad *et al.*, 1972; Gaur, 1975).

Composting material adds sufficient carbon in the soil that increases heterotrophic bacteria and fungal activity which contributes to soil enzyme activity that changes unavailable nutrient type into the available nutrient form. *Rhizobium* improved soybean (*Glycine max* L) can be produced by Combination of FYM, *Rhizobium* and PSB. Agricultural farming practices have different results on the bio-physiochemical properties of soil. Various researchers around the world have confirmed that organic farming has a higher population of microorganisms as compared to conventional farming (Ingham and Hu, 2002).

The organic amendments enlarge upon the beneficial soil microorganism's activity, it reduces the pathogen population, total carbon, cation exchange capacity and decreases soil bulk density, thereby eventually enhancing soil quality (Bullucket *et al.*, 2002). A study of Singh and Bohra 2009 has shown that the cropping system for rice-pea-black grams (*Vigna mungo* L.) has a higher population growth of bacteria, actinomycetes, and fungi than the rice-wheat cropping system. A comprehensive approach for Integrated Nutrient Management (INM) and integrated pest management (IPM) to input use efficiency in India, and eventually embracing region-specific promising cropping systems as an alternative method to organic farming for the production of various crops (Bhattacharya and Chakraborty, 2005).

According to the study conducted by Surekha *et al.*, (2009) the physical properties of soil under organic treatment are better than conventional farming. The study shows a decrease in the organic treatment than an inorganic farming system. Whereas, organic treatments have higher organic penetration resistance compared to inorganic systems. Tharmaraj *et al.*, (2011) reported soil fertility and their chemical and physical properties could be improved by using vermicompost and spraying of vermin-wash over control. This improves the water-holding capacity of the soil, moisture content , pH, EC, etc. In a study conducted in integrated nutrient management on soil fertility management by Naidu *et al.*, (2009) highest status of macro

and micronutrients in the treated soil, with 50% N through FYM + BF + Panchagavya 3% as a foliar spray was observed. In a study conducted by Ansari and Kumar, (2010) there is an increase in the content of organic C when vermin-wash and vermicompost are used as treatment followed by only vermicompost and cow dung. Nevertheless, higher nutrient content N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu was observed in the chemical fertilizer treatment followed by vermin-wash and vermicompost treatments (Ramesh *et al.*, 2010) studied the different states to compare the benefits of organic farming in terms of soil health, productivity, economics compared to conventional farms. The study results showed an overall improvement in soil quality with respect to soil's physical, chemical, fertility and biological properties. Different studies have concluded that the organic nutrients significantly increases the crop growth, yield, quality and soil qualities in a better manner and which significantly reflects on the soil microorganism and soil enzymes.

Effect on nutrient uptake

The long term over cropping and heavy use of chemical fertilizers without organic input deteriorates soil quality and cause environmental pollution and become a health concern (Albiach *et al.*, 2000). The soil quality can be enhanced by proper soil management by implementing organic farming practices. Organic agriculture can boost soil quality, increase microbial activity and recycle nutrients to produce high-quality crops. Thus, the organic farming system provides healthy plants (Knapp *et al.*, 2010; Dimitri *et al.*, 2012).

Increasing the microbial population alters the soil enzymes which play a significant role in soil biochemical reactions (Garcia-Gil *et al.*, 2000; Ros *et al.*, 2006). The cation exchange capacity and water retention capacity can be improved by humus production in organic farming (Weber *et al.*, 2007). Jat and Ahlawat (2006) reported that on the application of vermicompost in soil, there is an increase in the dry matter production directly on the first crop also results in residual effects on the next crop.Chaoui *et al.*, (2003) reported that slow-release organic fertilizer enhanced the relationship between nutrient availability and their requirement to increase plant biomass the synchrony between the plant’s nutrient requirements and nutrient availability hence increases plant biomass. Vermicompost contains a higher amount of nutrients which makes the macro and micronutrients available for plants result in increasing the uptake of nutrients (Nath *et al.*, 2009; Chauhan and Joshi, 2010; Shak *et al.*, 2014). Application of vermicompost increase bulk density and total porosity of soil as reported by Azarmi *et al.*, (2008).

Soil aeration and infiltration capacity of soil can be enhanced by an application of vermicompost as reported by Arancon *et al.*, (2008), it also provides a better root growing medium (Chaoui *et al.*, 2003). A crop's growth and yield can be improved by applying vermicompost, which will improve soil quality (Manivannan *et al.*, 2009). In a study conducted by Somasundaram *et al.*, (2007), a combined application of Panchgavya and biogas slurry shows higher N uptake in maize, sunflower and green gram. Higher uptake of primary nutrients was reported by Sanjutha *et al.*, (2008), integrated use of Panchgavya, Farmyard manure, and RDF. Foliar spray of vermin-wash in mulberry leaves increases the uptake of N and other nutrients as reported by Venkataramana *et al.*, (2010).

Conclusion

Adoption of organic farming system requires time and effort as compared to conventional farming. However, for the availability of food and conservation of resources to become sustained for long-run, organic farming is mandatory. The benefits of organic nutrient sources on soil physical, chemical, and biological properties are apparent from the previous literature, although prior knowledge careful management is necessary to avoid potential environmental impacts. Therefore, comparative study of various organic nutrient sources or their levels may be more beneficial in crop production and increasing farmer's income as compared to conventional sources of nutrients.

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