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Crop Performance and Soil Properties under Organic Nutrient Management

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ABSTRACT

The agricultural production in sufficient quantities in a sustainable way is the today's greatest challenge. The sustainable way here means without deteriorating the soil health. In current scenario, the cultivation of high yielding varieties with synthetic fertilizer and agrochemicals helping to produce required food demand of growing population but indiscriminate and imbalanced use of agrochemicals imparting negative effect on soil productivity, environmental health and food quality. It is therefore, important to use appropriate production system that produces good quality food in sufficient quantities without degrading the soil and polluting environment. The organic nutrient management favors soil health sustenance and environmental protection. However, the system has always been criticized for limitations with respect to crop performance in terms of yield. The subsequent modification and integration in organic nutrient management system increased its efficiency. The studies indicating the importance and benefits of organic nutrient management towards agricultural production and soil health sustenance has been reviewed in present work. The comprehensive review revealed that the organic nutrient management either sole or integrated is essential for optimum crop production and improving soil properties.

Introduction

Agriculture sector is the principal source of livelihood for more than 58% of the population and its contribution to the national GDP is 14.2% (DOA, 2019). India has only 2.3% share in world's total land area and has to ensure food security of about 17.5% of world population. Rapidly increasing population, shrinking land resources for crop production are putting tremendous pressure on land resource due to intensive cultivation

(Verma *et al.,* 2012). To meet the challenge, the farmers are forced to apply agrochemicals to adopted high yielding varieties. Fertilizers play an important role to meet nutrient requirement of the crop but their continuous use on lands will have deleterious effects on physical, chemical and biological properties of soil, which in turn reflects on yield.

Before the introduction of inorganic fertilizer manure was the primary source of nutrients for crop production. The long term and imbalanced chemical fertilizer and agrochemical application reported stagnation of crop yield and deterioration of soil health in terms of chemical and biological properties (Khandagle *et al.,* 2019a; Raghuveer *et al.*, 2017; Rajput *et al.*, 2016). Similarly, the cost of fertilizers has also increased which limits their application by farmers.

Considering the scenario, farmers wish to revisit the earlier nutrient management practices, but the limited nutrient supply capacity and bulk nature of organic inputs restricts them. The recent developments in organic nutrient supply packages either sole or integration there has been a renewed interest in use of organic nutrition. The interest is attributed to concerns for maintaining sustainable agricultural production while preserving the environment (Aher *et al.,* 2012).

Judicious application of nutrient especially organic manures not only improves the productivity (Sushila and Giri, 2000) and quality (Aher *et al.,* 2018b; Yashona *et al.*, 2018c) but also make cultivation sustainable (Wanjari *et al.,* 2004) because it is the basic source of soil organic matter. Soil organic matter plays pivotal roles in several processes of the soil ecosystem including nutrient cycling, soil structure formation, carbon sequestration, water retention and energy supply to microorganisms (Lakaria *et al.,* 2012). In present work, the research findings related to the effect of organic nutrient management either sole or integrated on crop performance and soil properties has been reviewed.

Crop performance under organic nutrient management

The organic nutrient for agriculture involves farm yard manure, cattle dung manure, poultry manure, pig manure, compost, vermicompost, city waste compost, municipal solid waste compost, green manure etc. Organic manure plays an important role in improving soil permeability to air and water and water stable aggregates. Thus application of organic materials such as farmyard manure considerably improves soil physical properties and nutrient uptake resulting in greater growth, yield and yield components (Satyanarayana *et al.,* 2002).

Organic nutrient application not only helps in maintaining soil health but also ensure sustainable crop production. Devi *et al.,* (2013) reported that the crop management through organic inputs produced significantly higher number of pods per plant and seed yield of soybean than inorganic and integrated practice. Similarly, the soybean showed 9.95% higher yield under organic sources of nutrients as compared to the application of inorganic fertilizers.

The increase in yield might be due to increased biological nitrogen fixation and solubilization of more amount of P by phosphate solubilizing bacteria and organic manure (FYM) also acts as a substrate for microorganisms and improved soil condition favorable for availability of nutrients to crop throughout the growth period (Dotaniya *et al.,* 2014; Prajapat *et al.,* 2014). Ramesh *et al.,* (2008) conducted a field experiment during 2004-05 to 2007-08 on deep Vertisols of

Bhopal and observed that, organic manure treatment recorded significantly higher seed yields, which were 10.6 and 11.2% higher than the chemical fertilizers. Significant increase in the yield of maize (Ali *et al.*, 2014; Mandale *et al.*, 2018c, 2018a), pigeon pea (Yashona *et al.*, 2018a) and wheat (Aher, 2018; Bhattacharyya *et al.*, 2008) with the application of organic nutrients has already been reported.

Hellal *et al.*, (2014) reported that the application of farmyard manure (FYM) influenced significantly the yield components of faba bean compared to mineral fertilizer, town refuse and biogas manure. Application of 5t FYM ha^{-1}improve plant growth and yield attributes of chickpea either numerically or significantly and increase grain yield over no application of FYM (Singh *et al.*, 2012). Davari and Sharma (2010) have previously reported a beneficial effect of FYM on wheat. Nutrient management plays a key role in improving crop yield with maintenance of soil fertility for sustainable production in intensive cropping.

Nutrient supplied to crop/plant in organic agriculture is differently viewed than in conventional agriculture. Datt *et al.*, (2013) reported the increase in organic carbon under the application of organic sources of nutrients. (Kanwar *et al.*, 2002) reported that application organic manure alone recorded higher organic carbon content than chemical fertilizers (NPK) applied treatments. The application of organic sources of nutrients also reported for higher uptake of nutrients in maize (Mandale *et al.*, 2019a), soybean (Aher *et al.*, 2019b), garlic (Raghuveer *et al.*, 2017), rice (Rajput *et al.*, 2016) and pigeon pea (Yashona *et al.*, 2018b). The higher uptake of nitrogen (Mandale *et al.*, 2019a), phosphorous (Mandale *et al.*, 2019b) and potassium (Mandale *et al.*, 2018b) under organic nutrient management has also been reported. Ali *et al.*, (2015) reported that the application of phosphorus at the of 120 kg ha^{-1} results in higher biomass yield (12753 kg ha^{-1}).

Soil properties under organic nutrient management

Soil physic-chemical properties

Organic farming systems rely on the management of soil organic matter which has greater influence on soil fertility, soil biological, physical and chemical properties of soil which in turn reflects in to crop yield and sustainability of system. Over-exploitation of soils over many decades has resulted in the exhaustion of the agricultural production systems and steadily declining productivity (Manna *et al.,* 2005).

Therefore, long-term sustainability and overall productivity of cropping systems are directly related to the maintenance of soil organic matter (Swarup, 2010). Organic manures are the greatest source of soil organic matter that influences the soil properties and its overall health. Ramesh *et al.*, (2008) reported that the application of organic manures significantly improved the soil organic carbon content compared to chemical fertilizers. The increase in soil organic carbon with the application of organic manure can be attributed to addition of higher biomass to the soil as of crop stubbles and residues. Increased soil organic carbon of soil due to application of manure was also previously.

Similarly, the soil nutrient availability is governed by soil adsorption and mineralization behavior (Mishra *et al.,* 2014; Yashona *et al.*, 2016). Rama Lakshmi *et al.*, (2011) observed that the accumulation of organic carbon was higher in the plot where farmyard manure was applied. The enhanced organic carbon increases the soil aggregation and physical properties (Aher *et al.*, 2019a).

Bayu *et al.,* (2006) also concluded that farm yard manure application increased soil organic carbon content by up to 67% over the control treatment. Long-term application of FYM contributed to the accumulation of organic matter in soil (Pikuła and Rutkowska, 2014). Singh *et al.*, (1999) reported that the continuous application of chemical fertilizer, decrease the organic carbon content in soil, where addition of 5 t FYM ha^{-1} along with fertilizer N helped in maintaining the original organic matter status in soil. The application of manure plays important role in improving soil organic matter (Mugwe *et al.*, 2009).

Long-term application of organic manures improved the soil organic carbon, available N, P and K in soil, thereby sustaining the soil health (Ramesh *et al.,* 2009). The nitrogen dynamics in soil is also governed by the soil organic matter. The application of farm yard manure reported for higher plant available nitrogen fraction in soil (Khandagle *et al.*, 2019b). Antil and Singh (2007) concluded from their study the application of organic manure alone or with NP fertilizers for 10 years resulted in an increased organic C content, available NPK and significant increase in DTPA extractable Zn, Mn, Fe and Cu. The increase in available N content with the addition of organic manures might be due to the release of nitrogen through the decomposition of organic manures.

Nagar *et al.,* (2016) reported that pH and EC reduced slightly with application of FYM and crop residues while significantly higher organic carbon, available nitrogen and potassium were recorded in FYM + phosphocompost and pigeonpea stalk + phosphocompost over RDF alone. Long-term manuring and fertilization registered significant increase in available soil organic carbon, total N P, K and S in the plots under 100% NPK + farmyard manure at 10 ton/ha (Katkar *et al.,* 2011). Singh *et al.,* (2005) concluded that the favorable soil conditions under treatments receiving organic manures might have helped in the mineralization of soil N leading to increase in available N content. Mann *et al.,* (2006) reported that available phosphorus content increased due to addition of FYM over initial and control. Beneficial role of FYM in improving the soil available P has long been observed and well established (Swarup, 2010).

The increase in available P of the soil resulting from the application of organic manures may be due to the mineralization of organic P, the production of organic acids which have a solubilizing effect on soil P and the organic amino which retard the fixation of phosphorus in soil (Gupta *et al.,* 1992). Sienkiewicz *et al.,* (2009) concluded that the application of manure for several years led to a three-fold increase in the available forms of potassium in soil as compared to the content determined after the application of mineral fertilization.

The higher availability of potassium may be due to beneficial effect of organic manures on the reduction of potassium fixation, added organic matter interacted with K clay to release K from non-exchangeable fraction to the available pool. The significant increase in the contents of potassium, calcium and magnesium in the surface layer of the soil after applying manure and slurry for many years (Edmeades, 2003). Bhattacharyya *et al.*, (2008) reported significant influence of organic manures application on soil micronutrient status as compared to conventional fertilizers application. Chaudhary and Narwal (2005) also reported that application of FYM significantly increased the DTPA extractable Zn, Mn, Fe and Cu. Application of farm yard manure significantly increased the concentration of Zn, B and Fe in the soil solution (Pikuła and Rutkowska, 2014).

Singh Brar *et al.,* (2015) concluded that the organic matter after decomposition release macro- and micronutrients to the soil solution, which becomes available to the plants, resulting in higher uptake.

Organic farming was capable of sustaining higher crop productivity and improving soil quality and productivity by manipulating the soil properties on long term basis. It was reported that organic and low-input farming practices after 4 years led to an increase in the organic carbon, soluble phosphorus, exchangeable potassium, and pH and also the reserve pool of stored nutrients and maintained relativity stable EC level.

Urkurkar *et al.*, (2010) concluded that supply of 100 per cent nitrogen in a rice-potato cropping system 1/3rd each from cow dung manure, neem cake, and composed crop residue appreciably increased the organic carbon ($6.3\ g\ kg^{-1}$) over initial value ($5.8\ g\ kg^{-1}$) as compared to supply from inorganic fertilizers alone.

Soil biological properties

The organic matter present in soil serves as food and shelter for microorganisms. The microbes can survive on different carrier material (Argal *et al.*, 2015). Nakhro and Dkhar (2010) observed maximum microbial population counts (fungal and bacterial) and microbial biomass carbon in organically treated plot followed by the inorganically treated plot and control. Mandic *et al.*, (2011) recorded highest count of soil microorganisms in solid manure treatment, which was significantly higher than that in the control and other fertilization treatments.

Dubey *et al.,* (2014) reported significant increase in population of fungi, bacteria, azotobacter, PSB and actinomycetes under 100% organic as compared to 100% inorganic nutrient management. Mader (2002) found higher microbial biomasses (Cmic), enzymatic activities and lower CO_2 values in organic than in plots under integrated management in a field trial. Aher *et al.*, (2018a) recorded 27-102% and 30-45% higher enzymatic activities and soil microbial biomass carbon, respectively under organic agriculture management as compared to inorganic agriculture management. Application of organic and inorganic treatments influences the rhizosphere microbial population.

The application of vermicompost resulted in most pronounced growth of microbial population compared to inorganic treatment (Das and Dkhar, 2011). Sudhakaran *et al.*, (2013) concluded that the β- glucosidase activities, soil respiration and microbial population (bacteria, fungi, actinimycetes, beijerinckia, azotobacter, rhizobium, bacillus and phosphobacteria) were higher in soils from organic farming than conventional farms.

Chang *et al.,* (2007) revealed that the soil microbial biomass, populations of bacteria, fungi and actinomycetes, as well as soil enzyme activities (dehydrogenase, acid and alkaline phosphatase) increased significantly in the compost-treated soils compared with the chemical fertilizer treated soil. Soil enzyme activities commonly correlate with microbial parameters and have been shown to be a sensitive index of long-term management effects such as crop rotations, animal and green manures and tillage (Bandick and Dick, 1999).

A higher level of dehydrogenase activity was observed in soil treated with vermicompost and manure compost compared with soil treated with mineral fertilizer has been reported. The positive effect of FYM addition on enzyme activities has been observed by

Böhme *et al.,* (2005). Datt *et al.,* (2013) reported that the dehydrogenase activity was significantly higher in organic and integrated treatments than the chemical one. Singh *et al.,* (2008) observed similar effect of organic manure.

FYM increases the activity because of its high biodegradability and micro-organisms addition. High dehydrogenase and phosphatase activity with application of FYM is attributed to higher content of organic matter.

Dehydrogenase is present in viable cells, and it is thought to reflect the total range of oxidative activity of soil microflora (Mandal *et al.,* 2007). Soil biological activity in terms of dehydrogenase and alkaline phosphatase enzyme were observed higher in organic manured compared to chemical either fertilizer or control treatments. Ramesh *et al.,* (2008) reported similar effect of increased enzyme activity of soil with the application of organic manures to pigeon pea crop. The phosphate activity was increased by the addition of organic materials.

Application of organic materials such as chicken manure, sheep manure and filter mud cake are emphasized by their beneficial effects on soil characteristics, macro and micronutrients availability and plant growth. Application of combined organic manures and effective microorganisms was positively affected of growth and yield of wheat plant (Brennan and Acosta-Martinez, 2019).

A comprehensive review of organic nutrient application either alone or integrated enhances the soil organic carbon. The soil organic carbon acts as a source of food and shelter for microorganisms. The increased microbial population and enzyme activities results in higher nutrient availability which reflected in terms of better crop performance.

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