A review: Impact of organic farming practices on soil organic matter

Abstract

Organic farming plays an important role in the improvement of soil organic matter content. Adoption of organic farming leads to overall balance of the ecosystem and sustaining environmental health. Although conventional farming practices are quite better in achieving global food security, the adoption of organic farming is beneficial in terms of long-run ecosystem balance. Organic farming largely excludes the use of synthetic fertilizers, pesticides, genetically modified crops and feed additives. Organic farming is an important tool to reverse the trend of declining soil organic matter status in the soils. It is mediated by returning plant residues and manures from livestock back to the land, enhancing biological nitrogen fixation by legumes, and versatile crop rotations. Soil organic matter (SOM) balances are the most common decision support tools in organic farming management. The concentration of soil organic matter often serves as a foundational attribute that controls many soil properties. In organically managed systems where no synthetic fertilizers are allowed, soil microbial biomass is important to supply plant nutrients by mineralization processes and to avoid nutrient leaching. The soil organic matter is affected by land use practices, soil depth and climatic conditions under organic farming.

Key word: organic farming, soil organic matter, climatic conditions, soil depth

Introduction

Organic farming is the system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste (Gopinath *et al*., 2022). Organic farming systems often comprise crops and livestock, recycle farmyard manure for fertilization, and preventive or bio-control measures are used for plant protection. Organic farming has the potential to arrest progressive degradation of soil health by restoring, maintaining, and enhancing natural processes and cycles in harmony with the environment. As a low-input, alternate agriculture system, fertilization is brought about by a strong reliance on closed on-farm nutrient cycling in organic farming systems. It is mediated

by returning plant residues and manures from livestock back to the land, enhancing biological nitrogen fixation by legumes, and versatile crop rotations. Thus, organic farming could improve soil biological function and nutrient cycling and may help to reverse declining trends in soil fertility by improving the soil organic matter (SOM) status. SOM balances are the most common decision support tools in organic matter management. The concentration of soil organic matter often serves as a foundational attribute that controls many soil properties. Soil organic matter degradation is an emerging concern that should not be neglected. Organic farming works as a sustainable method for improvement of soil organic matter without deteriorating the environmental quality. The requirement of fresh organic matter will be higher with organic farming (Leithold *et al.*, 2015).

Soil organic matter basically consists of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and the substances that are synthesized by soil microbes. Including these, the living organisms that are smaller than 2 mm are also regarded as part of soil organic matter. Soil organic matter should not be considered as a single entity. It is complex and heterogeneous, composed of a continuum of organic materials, stabilized to varying degrees by molecular recalcitrance, physical separation from the microbial biomass and/or direct association with inorganic ions and clay surfaces. Many researchers found that soil quality, that is the capacity of a soil to perform within the ecosystem and land-use boundaries, to maintain the biological productivity, environmental quality and improvement in plant and animal health, is being promoted by soil organic matter. For sustainable development, it is important to improve the land use systems to improve the soil organic matter, reduce the soil erosion and soil degradation and finally improve crop production. Organic farming which involves various components such as crop rotation, use of biofertilizers, on-farm sources, organic manures, livestock, green manuring, etc. will ultimately lead to increment in soil organic matter which on decomposition releases various nutrients in soil and thus enhances the soil fertility. In organically managed systems where no synthetic fertilizers are allowed, soil microbial biomass is important to supply plant nutrients by mineralization processes and to avoid nutrient leaching. Increase of about 100% to 300% in soil microbial biomass with adoption of organic farming can be obtained (Santos *et al.*, 2012) which occurred due to the more organic C inputs in organically managed soil. The soil with depleted organic matter content and being restored with organic amendments have lower

critical threshold level for crop yield as compared to soil without amendments (Lal, 2020). Organic farming is an efficient tool for environmental sustainability as it is associated with no environmental concern, maintains the yield stability, and has no use of synthetic fertilizers. In spite of various technologies for soil health, organic farming is one of the best approaches for long-term ecosystem sustainability and enhanced soil organic matter content.

Various organic treatments and soil organic matter

The various components of soil organic matter will improve the soil organic matter at varying rates (Table 1). The regular addition of farm yard manure (FYM) enhanced the labile soil organic matter pools (dissolved organic carbon, light fraction, microbial biomass carbon) after 45 years of organic farming in each season (Laik *et al*., 2021). The improvement in soil organic matter is much more observed in the summer season as compared to the winter season which is due to the varying decomposition rate of added organic matter into the soil. The decomposition process will be faster with high temperature and optimum moisture conditions. The green manuring will substantially have higher production of dry matter within less time period which ultimately enhances the soil organic matter content (Dubey *et al*., 2015). Although the best results of green manuring can be observed under arable soil where the soil aeration is sufficient for its decomposition. The cow dung and farm yard manure provide the best results over the green manuring under submerged conditions (Banik *et al*., 2006). The adoption of crop rotation along with organic manures resulted in higher organic matter content as compared to the adoption of only legume based organic cultivation (Marriot and Wander, 2006).

Organic farming under various land use practices and soil organic matter accumulation

The type of land use under organic cultivation resulted in different levels of soil organic matter accumulation under the same climatic conditions. Although conventional farming resulted in food security and enhanced fibre supply for human demand , the conversion of land from conventional to organic farming resulted in long-term sustainability. The transitional period while moving from conventional to organic farming is necessary to understand and evaluate whether adoption of organic farming is successfully proceeding or not. The higher accumulation of soil organic carbon and total nitrogen have been reported by various authors under organic farming as compared to the conventional system (Berner *et al*., 2008; Lagomarsino *et*

al., 2009; Leite *et al*., 2010). The transition from conventional to organic farming resulted in higher microbial biomass carbon (MBC), microbial biomass nitrogen (MBN) and improvement in recalcitrant organic matter fractions (Santos *et al*., 2012). The distribution of soil organic matter is affected by land use practices.

Table 1: Effect of various organic treatments on soil organic matter (%) and crop yield (t/ha) under different soil texture

Treatment	Soil type	Initial soil organic matter (%)	Soil organic matter (%) after organic farming	Crop	Crop yield (t/ha)	Reference
Cow dung	Sandy loam	0.56	0.79	Rice	4.11	Banik *et al.*, 2006
Farm Yard Manure (FYM)	Loamy sand	0.42	1.92	-	-	Laik *et al.*, 2021
FYM	Sandy clay loam	0.43	0.60	Pigeonpea	0.8	Gopinath *et al.*, 2022
Crop rotation with legumes	Silty loam	1.34	2.2	Broad bean	15.4	Melero *et al.*, 2006
Sesbania	Sandy loam	0.56	0.65	Rice	3.56	Banik *et al.*, 2006

The soil organic matter content was higher under wheat-pearl millet cropland as compared to the grassland and teak-wood land under agro- organic farm (Pathak and Reddy, 2021) in surface layer, while the pattern was different at deeper soil layers which might be due to variation in their rooting behaviour. The variation in soil organic matter content might be due to the addition of different organic manures in cropland cultivation. In case of grassland and teak-wood land, the addition of leaf manure is the only added organic source thus there will be lower soil organic matter accumulation at upper layers, while their deeper root penetration resulted in more soil organic matter accumulation at lower depths due to addition of more root biomass. Emiru and Gabrikidan (2013) also reported that higher organic matter content was

found under forest land as compared to grassland and shrubland under organic cultivation.

Soil texture as transformed by organic matter

The organic farming cultivation under different soil texture resulted in varying rate of soil organic matter accumulation. The fine textured soil under organic cultivation will result in more soil organic matter accumulation as compared to the coarse textured soil under same organic cultivation practices.The fine textured soils have high clay content that will hold more organic matter content. The various functional groups (such as carboxylic, aldehydic etc.) present in humic substances (fulvic acid, humic acid, humin) will bind with clay particles and thus clay will be responsible to hold more organic matter content. The organic matter in turn is responsible for improving the available nutrient status, water holding capacity and structural stability of the soil (Sheoran *et al*., 2019).

Organic farming, soil organic matter and crop yield

Organic farming is beneficial to sustain the soil health and thus leads to enhanced crop production. The crop yield due to adoption of organic farming will be lower during the initial phase (Das *et al*., 2017) but it improved after the transitional phase of about 3 years with continuous adoption of organic practices (Santos *et al*., 2012). Adoption of organic farming successfully increased the yield of rice (Banik *et al*., 2006) with addition of cow dung, FYM and paddy straw in sandy loam soils, whereas the reduction in yield was recorded under conventional practices. This change was due to the reason that organic practices not only provide major nutrients to the soil, but also supply various micro-nutrients, on decomposition of organic matter, which are essential for plant growth and that are commonly not supplied by the synthetic fertilizers. The addition of organic amendments in soils which are depleted of their organic matter content, results in lower critical threshold (the point below which the yield starts to decline) level as compared to those without organic amendments (Lal, 2020). Several other authors (Pan *et al*., 2009; Melero *et al*., 2006; Gopinath *et al*., 2022) also reported that organic farming resulted in improvement of soil organic matter content which improves the crop yield.

Conclusion

Soil organic matter balances are the most common decision tools in organic farm management. The fresh organic matter demand is higher with organic farming as compared to conventional farming which must be considered while adopting the

organic farming. The quantity of soil organic matter content is affected by the period of organic farming. More will be the year under organic cultivation; more will be the organic matter content. The crop yield stability in the long run was observed with organic farming as compared to conventional farming. The soil with depleted organic matter content and being restored with organic amendments have lower critical threshold level for crop yield as compared to soil without amendments. Organic farming when practiced on soil with low organic matter content under various land use resulted in accumulation of higher organic matter content as compared to conventional. The organic farming thus resulted as an important strategy for improvement of soil organic matter content under long run and thus sustaining the overall ecosystem balance.

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