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The Impact of Organic Amendments on Fruit Crop Production: A Comprehensive Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

This review aims to provide a comprehensive overview of the current state of knowledge on the effects of organic amendments on fruit crop quality and soil health, with a focus on identifying areas for future research. Organic fruit crop production additives are continuously gaining popularity due to increased demand for high-quality fruits and sustainable agricultural practices. Organic amendments such as compost, manure, and green manure along with biofertilizer have been shown to enhance soil properties, thus enhancing fruit quality, yield, and nutritional content. They also facilitate microbial diversity, soil fertility, and water-holding capacity, which promotes

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sustainable agriculture and reduces dependence on artificial fertilizers. However, farmers might face some challenges including the high price of the inputs, uneven quality, and possible environmental hazards such as heavy metal deposition. Future research must focus on designing cost-effective and environmentally sustainable means, improving the consistency and quality of organic fertilizers, and examining their interaction with other sustainable agricultural practices. By solving these problems, organic amendments may become a cornerstone of sustainable fruit crop production, benefiting both the environment and human health.

Keywords: Compost; crop production; organic amendments; soil fertility.

1. INTRODUCTION

With the rising demand for quality fruits and the importance of a healthy ecosystem, a growing trend towards more sustainable agricultural methods is emerging. The unprecedented rates of soil erosion, loss of biodiversity, and contamination of the environment have underscored the necessity to shift agricultural trends toward sustainability, equity, and environmental conservation. In this light, organic amendments have been suggested as a useful option to enhance the quality of fruit crops as well as build soil health. Soil health and quality are foundational to agricultural sustainability and meeting global food security priorities. However, intensive farming practices have degraded soil ecosystems. Organic amendments and regenerative management practices can restore soil function by overcoming nutritional limitations, improving physical and biological properties, and promoting general soil and crop resilience (Singh et al., 2024). Soil quality is most simply defined as “the capacity of the soil to function”. Important soil functions include: water flow and retention, solute transport and retention, physical stability and support; retention and cycling of nutrients; buffering and filtering of potentially toxic materials; and maintenance of biodiversity and habitat (Lehman et al., 2015; Daily et al. 1997). Organic amendments, which are obtained from natural materials like animal manure, compost, and green manure, have been found to possess many advantages in the production of fruit crops. Organic amendments supply plants with necessary nutrients, enhance soil structure, fertility, and diversity, and provide a favourable environment for maximum plant growth (Luo et al.,2018). Organic amendment application in fruit crop production has been found to improve fruit yield, quality, and shelf life, as well as alleviate soil degradation, decrease dependence on synthetic fertilizers, and enhance ecosystem services.

Soil microbial populations contribute to a large extent to the earth's biodiversity and participate in a range of ecosystem processes, including decomposition of organic matter, nutrient cycling, and plant productivity (Bender et al., 2016). As alternatives to chemical fertilizers, organic amendments (such as livestock dung, crop residues, compost, green manure, and their mixtures) are viewed as a sustainable agronomic practice since they enhance not only crop productivity and soil fertility but also microbial biomass and related processes (Li et al., 2021).

These natural origin-based amendments are broadly categorized into two types: natural organic amendments and processed organic amendments (Tilman et al., 2002). The former includes items such as compost, manure, and green manure, while the latter comprises products such as fish emulsion and bone meal. Compost, an omnipresent organic amendment, is a nutrient-rich product generated via the microbiological breakdown of organic matter (Epstein, 2011).

Manure, yet another dominant organic amendment, originates from animal dung and is differentiated by high nutritional content, notably nitrogen and phosphorus (Chadwick et al., 2015). Green manure, where cover crops are ploughed into the soil, is also a highly useful organic amendment since it deposits organic matter, controls pests and diseases, and delivers nutrients into the soil (Snapp et al., 2005). The nature of organic amendments is complex and shaped by source material, composition, and handling operations (Hartmann et al., 2015). For example, compost is generally alkaline, having a pH level of 6.5-8.5, while manure may have a more fluctuating pH trend (Bernal et al., 2009).

Organic amendments further vary in their nutrient composition, such that some contain a balanced combination of macronutrients, whereas others might be more specific in their nutrients (Ayamba et al. 2023). In addition, these amendments can contain a variety of microorganisms, which are

important in decomposing organic material and providing nutrients to plants (Goyal et al.,1999). Micronutrients play an important role in crop production due to their essentiality in plant metabolism and the adverse effects that manifest due to their deficiency (Bijay et al., 2023). Besides affecting plant growth, micronutrients also play a major role in disease resistance in cultivated crop species. Micronutrients can tremendously boost crop yield and improve the economy and post-harvest life of horticultural produce (Raja, 2009; Savdhariya et al. 2024). The proper application of organic amendments can have long-term effects on soil health and plant growth (Bronick & Lal, 2005). Through the addition of organic matter, such amendments can enhance soil structure, raise water-holding capacity, and promote the activity of beneficial microorganisms (Bronick * Lal, 2005). Organic amendments may also offer a slow release of nutrients, limiting the use of synthetic fertilizers and the potential for environmental contamination (Tilman et al., 2002). Finally, the strategic incorporation of organic amendments into farm practices can assist in the formation of more environmentally friendly and sustainable farming systems.

However, the effectiveness of organic amendments can be influenced by various factors, including soil type, climate, and crop species. Additionally, the variability in the composition and quality of organic amendments can impact their effectiveness in promoting soil health and fruit crop quality. This review aims to provide a comprehensive overview of the current state of knowledge on the effects of organic amendments on fruit crop quality and soil health, with a focus on identifying areas for future research.

2. EFFECTS OF ORGANIC AMENDMENTS ON SOIL HEALTH

The addition of organic amendments to the soil has been demonstrated to have a significant effect on the physical attributes of the soil. The addition of compost, for example, has been proven to enhance the structure of soil, which enhances the water retention capacity of the soil and minimizes soil erosion (Liu et al., 2012). Likewise, green manure has also been found to increase soil aggregate stability, hence improving the infiltration and retention of water by soil (). Such soil physical property improvements can significantly affect plant growth and productivity. Soil chemical properties are also significantly affected by organic amendments.

For example, the addition of manure has been found to increase soil pH, reducing soil acidity and improving nutrient availability (Chadwick et al., 2015). Compost, on the other hand, has been shown to increase the availability of nutrients such as nitrogen, phosphorus, and potassium, thereby improving plant growth and productivity (Epstein, 2011). In addition, organic amendments have been shown to decrease the necessity for synthetic fertilizers and thereby lower the chances of environmental pollution. Apart from affecting the physical and chemical properties of the soil, organic amendments also significantly affect the biological properties of the soil. For example, the incorporation of compost has been shown to enhance microbial activity and increase the activity of beneficial microorganisms, thus enhancing the health of the soil (Goyal et al.,1999).

In papaya, the use of 7 kg urban compost/plant or 10 kg FYM/plant was found to be optimum for soil health in terms of microbial population, and biochemical reaction as compared to other treatments (Reddy et al.,2010). Singh et al. (2012) observed that the soil parameters in terms of pH, EC, bulk density, hydraulic conductivity and organic carbon in the NA-7 Aonla orchard were also significantly improved by various sources of organic nutrients. Significant improvements in the physical and chemical properties of the soil were observed by the application of various sources of organic nutrients. Similar findings were reported for guava where the use of neem cake in combination with *Azotobacter* dramatically improved the yield.

The use of organic manures combined with bio-fertilizers greatly raised the population of microorganisms in the soil which enhanced the health of the soil and consequently the plant growth and productivity (Mitra et al., 2012) Generally, the addition of organic amendments to soil has been found to play a major role in enhancing soil health, both physically, chemically, and biologically. By facilitating the development of favourable microorganisms, enhancing the availability of nutrients, and minimizing the use of synthetic fertilizers, organic amendments can help take a leading role towards stimulating sustainable agriculture and enhancing environmental health.

3. EFFECTS OF ORGANIC AMENDMENTS ON FRUIT CROP YIELD

The use of organic amendments has been well acknowledged as an effective measure to increase fruit crop production. Many research works have proven that the use of organic amendments, including compost, manure, and green manure, can notably increase fruit yield by enriching soil fertility, structure, and water retention capacity (Liu et al., 2012). A study by Dutta et al. (2010) found that various treatments of biofertilizers significantly enhanced the fruit yield as Azotobacter + Azospirillium + Vesicular Arbuscular Mycorrhizae (VAM) + 2 kg FYM exhibited maximum number of fruits per plant (19.72 no.s) followed by *Azotobacter* + VAM + 2 kg FYM in papaya.

The response of yield to organic amendments may be affected by several factors such as soil type, climate, and crop species. For instance, a cavendish banana study found that showed that improved yield with early cropping was achieved when inorganic fertilizers (100:100:150g NPK/plant/year) and organic manures (10kg poultry manure/plant) were used as compared to inorganic fertilizer applications alone (Tirkey, et al., 2002) Likewise, a strawberry var. Senga Sengana, Nazir et al. (2012) stated that, with the application of Poultry manure + *Azotobacter* + wood ash + phosphorus solubilizing bacteria+ oil cake, the maximum yield of fruit was achieved (132.75 q/ha), followed by Poultry manure + Azospirillum + Wood ash + phosphorus solubilizing bacteria + oil cake. These results highlight the need to take into account the particular soil, climate, and crop type when choosing organic amendments to maximize fruit production. Aiyelaagbe et al. (2012) discovered that, in pineapple relative to no application of poultry manure (PM), the application rate of 5 t poultry manure/ha doubled fruit yield (41 t/ha) and additional yield increments at greater poultry manure (PM) rates were minimal. For a maximum yield of pineapple in Southwestern Nigeria, the use of poultry manure at 15 t/ha (10 t at planting and 5 t/ha 10 months later) is recommended.

Mitra et al. (2012) disclosed that, in guava, the application of neem cake in combination with Azotobacter tremendously enhanced the yield, fruit size and quality of fruit. Organic manures used in combination with biofertilizers greatly enhanced soil microbial population that enhanced the soil health and thus the growth and productivity of the crop. A comparison between responses of organic and inorganic amendments has indicated that organic amendments can be equally effective as inorganic amendments for fruit yield promotion. For instance, research on mandarin revealed that the use of filter mud (FM) or farmyard manure (FYM) on "Balady" mandarin trees in sandy soil, enhanced fruit set, yield, and fruits per tree (Ebrahiem and Mohamed, 2000). Likewise, research conducted on guava revealed that the use of manure raised the fruit yield by 30%, and this was more than the increment in yield as a result of the use of inorganic fertilizers (Kumar et al., 2009).

From these results, it can be concluded that organic amendments can also be an efficient substitute for inorganic fertilizers to enhance fruit yield. Organic amendment application has a great effect on the yield of fruit crops, and yield response can be determined by different factors such as soil type, climate, and crop species. A yield response comparison to organic and inorganic amendments has concluded that organic amendments can be as effective as inorganic amendments in promoting fruit yield. Hence, the utilization of organic amendments can be a good approach for enhancing fruit yield, while simultaneously supporting sustainable agriculture and environmental pollution reduction.

Effects of Organic Amendments on Fruit Crop Nutritional Content: The application of organic amendments has been shown to have a positive impact on the nutritional content of fruit crops. Organic manures like compost, manure, and green manure have the potential to deliver essential nutrients, including vitamins, minerals, and antioxidants, that are necessary for the support of maximum fruit quality and human health (Kumar et al., 2009). For example, banana was reported to be affected when Azospirillum and Azotobacter inoculated cv. Giant banana plants were used, resulting in fruits with increased Total Soluble Solids (TSS) and reducing sugars (Tiwary et al. (1998). El-Morsy (1997) discovered that the mean cluster weight, berry weight, berry length and berry width of "Banaty" grapevines, were significantly enhanced with increasing the number of organic fertilizer sources as filter mud and sewage sludge and the chemical traits of fruits for "Banaty" grapes namely total soluble solids, total sugars and total acidity were enhanced on application of organic sources. Its quantities were increased by raising the total soluble solids and total sugars values and the total acidity was tending towards the

opposite trend. The influence of organic amendments on fruit crop nutritional content is due to the enhanced nutrient uptake and utilization by the crops.

Organic amendments may deliver a slow release of nutrients, which may cause nutrient use by the plants to be more efficient (Liu & Liu, 2012). Moreover, organic amendments also enhance the physical, chemical, and biological properties of the soil which can result in a favourable environment for plant development and nutrient absorption (Kumar et al., 2009). For instance, an experiment on guava showed that the incorporation of green manure enhanced the antioxidant capacity of the fruit by 25% compared to the control treatment (Li et al., 2019). Highest total soluble solids (6.20°Brix), total sugar (5.18%) and carotene (2320 µg/100 g pulp) content were obtained from Azotobacter + Azospirillum + VAM + 2 kg FYM with lowest acidity in papaya (Dutta et al., 2010) A comparison of the nutritional value of organically and conventionally produced fruit crops has concluded that organic production can lead to higher quality fruit. For example, a mango study revealed that treatment with nitrogen (96g) + Azotobacter (CBD-15) gave fruit weight (150g), T.S.S (23.64%), and ascorbic acid (45.53mg per 100g pulp) (Feza et al., 2003).

A study on grapes also revealed the positive impacts of biofertilizers such as rhizobacterium and nitrobein on berry set, yield and quality of berries for "Red Roomy" grapevines Akl et al. (1997). These results imply that organic production systems can lead to greater contents of some nutrients, which will have human health benefits. Dutta et al. (2009) found that, in guava inoculation of Azospirillium and VAM and also inorganic fertilizers was found to be effective in bringing enhancement in the content of total soluble solids, total sugars and ascorbic acid in fruits while acid content reduced through inoculation of bio-fertilizers. The treatment optimized the biochemical components of fruits over inorganic fertilizer alone and control. Hence, it is recommended to use inorganic fertilizers in combination with the bio-fertilizers, i.e., VAM and Azospirillium under integrated nutrient management practices of guava cultivation in order to get maximum fruit yield with better quality.

In apricot the combined application of bio-fertilizer (60 g/tree), vermicompost (30 kg/tree), cow urine (12.5%) as foliar spray and 50 % NPK considerably enhanced leaf total N, P, K, Ca, Mg, Fe, Cu, Zn and Mn content and was significantly raised by 30.4, 109.5, 31.6, 33.5, 65.7, 34.6, 71.9, 47.5 and 31.3 per cent respectively above control in conventional “New Castle” variety (Singh et al., 2012).

Moreover, the use of organic amendments can have a beneficial effect on the nutrient quality of fruit crops. Organic amendments can offer required nutrients, enhance nutrient absorption and utilization, and lead to greater concentrations of certain nutrients in contrast to standard production practices. Thus, the application of organic amendments can prove to be a suitable option for enhancing the nutritional value of fruit crops, with potential beneficial effects on human health and sustainable agriculture.

Challenges and Future Directions: Although there are lots of advantages to using organic amendments in fruit crop production, a number of challenges and limitations have to be solved. One of the most serious challenges is that organic amendments are very expensive and can render them less competitive than synthetic fertilizers (Kumar et al., 2009). Moreover, the direct use of certain untreated agricultural residues or immature composts can cause adverse effects on plant growth by having relatively high proportions of soluble organic compounds (Paradelo et al., 2024). In addition, the nature of organic amendments can differ considerably based on source and production methods, which can affect their capacity to enhance plant growth and soil health. Further, the application of organic amendments has also been seen to result in the buildup of heavy metals within the soil, causing potential harm to human health as well as the environment (Kumar et al., 2009).

Despite, it is not an extended problem in agricultural waste but some materials such as animal manure can have high concentrations of certain metals due to their presence as feed additives (Leclerc et al., 2017) and can lead to the deposition of heavy metals particularly in the long term. For instance, soil Cd, and Pb have been increased after three consecutive years of application of chicken and swine manure; consecutive applications for six years of swine compost also led to considerably greater levels of Cu and Zn than the control (Zhao et al., 2006). Hence, strategies to reduce the environmental effects of organic amendments are important to be developed. Another difficulty of using organic

amendments is the risk of environmental contamination. For instance, using manure as an organic amendment will result in the emission of greenhouse gases like methane and nitrous oxide, which are responsible for global warming.

Problems from organic amendment use likewise come from the heavy metals and from the inability to regulate the conversion processes needed to get N and P in their organic form to convert into the mineral form utilized by crops, and specifically to keep such losses of the nutrients to a minimum that are in a form posing a health risk to human. Thus, it is critical to come up with ways of reducing the environmental effects of organic amendments (Santosh, 2007). To achieve this, future research agendas ought to aim at developing low-cost and environmentally friendly production techniques for organic amendments. Research should also aim at enhancing the quality and uniformity of organic amendments as well as at coming up with ways of reducing their environmental effects (Liu et al., 2012). In addition, studies must also investigate the possibility of applying organic amendments together with other sustainable farming practices, including conservation tillage and cover cropping, to enhance soil health and plant growth.

4. CONCLUSION

Though organic amendments have numerous advantages in fruit crop production, there are also numerous constraints and challenges that must addressed. Through the creation of affordable and sustainable ways of production, the enhancement of quality and consistency of organic amendments, and the reduction of environmental footprints, we can enhance the uptake of organic amendments and achieve the sustainability of fruit crop production This review has emphasized the significance of organic amendments to enhance soil health, promote fruit yield, and enrich the nutritional quality of fruit crops.

Organic amendments, including compost, manure, green manure along biofertilizer have the potential to enhance soil physical, chemical, and biological attributes, resulting in enhanced plant growth and productivity (Buzinaro et al., 2009). the application of organic amendments can also enhance the nutritional value of fruit crops, conferring health benefits to consumers (Li et al., 2019). Furthermore, the use of organic amendments can also reduce the use of synthetic fertilizers, hence environmental pollution and promoting sustainable agriculture. Therefore, the utilization of organic amendments in fruit crop production can render the food system more sustainable and environmentally friendly.

This review identifies the need for further research on the use of organic amendments in fruit crop production. Subsequent research needs to emphasize studying the long-term impacts of organic amendments on soil fertility and plant growth and studying the possibilities of using organic amendments in combination with other sustainable agriculture practices (Liu et al., 2012). Further, research must also aim at coming up with affordable and sustainable production practices for organic amendments so that they can become available to small-scale farmers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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