Review Article

Effect of Organic Fortification on Soil Health: A Review

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Submission :25.04.2025 Acceptance : 31.05.2025 Publication : 01.07.2025

Abstract:

Soil health plays a critical role in maintain sustainable agricultural systems and ensuring long-term food security. Organic fortification, which involves the addition of organic materials such as compost, manure crop residues, vermicompost, green manure and biochar to soil, has emerged as a key strategy for enhancing soil fertility, structure and biological activity. This review article aims to explore the benefits, challenges, and practical applications of organic fortification in improving soil health and the effects of organic manure on various soil properties, including physical, chemical, and biological parameters. The review elucidates the complex interactions between organic manure and soil, highlighting the impacts on soil structure, nutrient availability, microbial activity, and overall soil health. The paper also discusses the role of organic amendments in promoting sustainable agriculture, the mechanism behind their impact on soil, and potential avenues for future research.

Key words: Organic fortification, Sustainable agriculture, Agroecosystem, soil health

Introduction:

Soil health is a vital component of agricultural productivity and environmental sustainability. The depletion of soil organic matter (SOM) due to intensive farming practices, deforestation, and urbanization and over use of inorganic fertilizer led to soil degradation, erosion and loss of fertility, posing significant challenges to long-term agricultural sustainability[(1)]. In response to these challenges, there has been a growing interest in alternative agricultural practices aimed at enhancing soil health while minimizing environmental impacts. Among these practices, the use of organic manures has gained considerable attention due to its potential to improve soil properties, promote nutrient cycling and mitigate the negative effects of chemical fertilizers. Organic manures, derived from plant and animal sources, represent a rich source of organic matter, essential nutrients and beneficial microorganisms. Though the concentration of nutrient is less so to improve concentration of nutrients and efficiency fortification of organic manure is necessary[(2)].

Fortification of organic manure means to increase its efficacy so that the soil is enriched from basic, macro and micronutrients to well development and growth of crop and enhance the biological activities inside the soil. When applied to soil, organic fortified manures can influence a wide range of soil properties, including physical, chemical, and biological characteristics [(3)]. Understanding the effects of organic manures on soil properties is crucial for optimizing their use in sustainable agriculture and mitigating the adverse effects of conventional farming practices. Organic fortification offers a natural and sustainable solution to restore soil health, reduce dependency on chemical fertilizers, and improve soil carbon sequestration. Organic amendments enhance microbial diversity, increase soil fertility, and improve soil structure, thereby fostering healthier, more resilient ecosystems[(4)]. This review aims to provide a comprehensive overview of the current state of knowledge regarding the impact of organic manures on soil properties. Through a synthesis of recent research findings, we will explore the effects of organic manures on soil fertility, structure, moisture retention, microbial activity, and carbon sequestration

Advantages of fortification

- The overall costs of fortification are extremely low; the price increase is approximately 1 to 2 per cent of the total component value.
- Fortified components have more effective than genuine component.
- Provides nutrition without any change in characteristics of the component.
- Increase the solubility of phosphatic fertilizers.
- Reduce the quantity of applied compost or vermicompost.
- Its not required extra labor or wages or capital.
- This can be done very easily.

Literature Review

General overview of organic fortification materials:

Types of Organic Nutrient Resources

Organic nutrients are exactly that-nutrients developed from living organisms or their waste products. They are essential for the rapid growth and improvement of plants and animals[5]. Some types of organic nutrient resources given below in Figure 1.

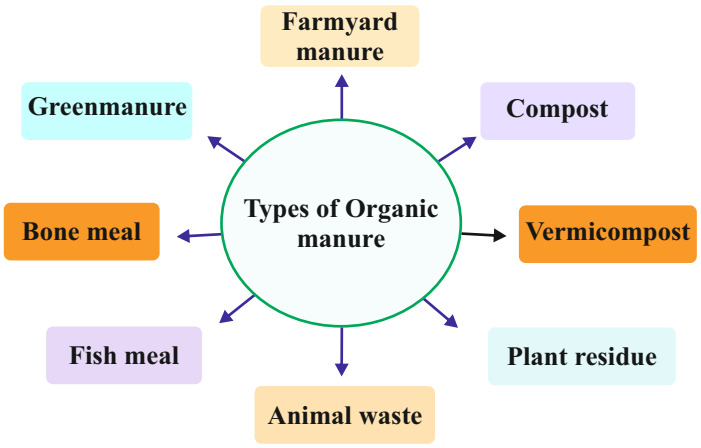


Figure 1 : Types of Organic Nutrient Resources

Compost:

Compost is a mixture of decaying organic matter that is used as a organic fertilizer. It is made from a selection of organic materials, like crop residues, farm yard waste, and manure[6]. Decomposed organic matter rich in nutrients, compost provides essential micronutrients and macronutrients to the soil, improves soil structure, and promotes microbial activity. The average nutrient contents of compost are 0.95% N, 0.58% P_2O_5 and 0.95% K_2O although it varies depending on the types of compost (farm and town compost). Research shows that compost enhances soil's water-holding capacity, reduces erosion, and boosts plant growth [7].

Composts become fortified compost after nutrient enrichment and blending with Plant growth-promoting rhizobacteria (PGPR), presence of PGPR in the rhizosphere significantly increases plant growth and yield under nitrogen limiting conditions. This new technology can certify the lower application rates of compost (300-500 Kg/ha as compared to the normal application of 1-2 tonnes/ha) and can reduce up to 50 % of the recommended dose of inorganic fertilizers[8].

Manures/Animal Waste: Animal waste, such as poultry manure, cow dung, sheep and goat manure and horse manure, is an abundant source of organic nutrients. It is frequently utilized for soil fortification. Manure increases nutrient availability, organic matter content, and microbial biomass, which collectively enhance soil health and productivity.

Plant Residues: Plant biomass is a additional sources of organic nutrients include plant leftovers like leaves, stems, and roots into the soil helps replenish organic matter, improves soil aggregation, and supports soil organisms. This practice not only recycles nutrients but also reduces soil erosion and enhances soil water retention[9].

Green Manure: The practice of ploughing or turning into the soil undecomposed green plants tissue for purpose of improving physical condition as well as fertility of soil referred as green manuring and manure obtained by this method known as green manure. This particular kind of cover crop is planted with the intention of enhancing soil fertility. Usually, when it's still green, it gets plowed under, enriching the nutrient-rich, organic-rich soil [10].

Fish Meal: Non-edible carcasses of fish and offal are used to prepare fish meal. It is available either as dried fish or fish meal or powder. It is an excellent resource for potassium, phosphorus, and nitrogen [11].

Bone Meal: Crushed animal bones are used to make bone meal, which is high in calcium and phosphorus. It is frequently applied as fertilizer to vegetables and flowering plants

Blood meal: Dried blood or blood meal is by product of slaughter house. It contains 10 to 12 % available Nitrogen and 1 to 1.5 % Phosphorus and 1.0 % potassium. It is very quick acting manure and effective on all types of soil.

Effect of organic manures on soil physical properties

Organic manure application significantly influences various soil physical properties, including bulk density, porosity, soil structure, and water retention capacity, ultimately impacting soil health and agricultural productivity. Here's a detailed overview of the effects of organic manure on soil physical properties:

Bulk Density: Bulk density of soil is an index of soil compactness Organic manure incorporation tends to reduce soil bulk density, by enhancing soil aggregation and pore formation[12]. The addition of organic manure improves soil structure, leading to better soil porosity and reduced compaction. Through application of compost and FYM in the soil, soil bulk density could be improved and in turn, this may

lead to improvement of soil porosity. Organic manure incorporation leads to reduce soil bulk density, by enhancing soil aggregation and pore formation. The addition of organic matter improves soil structure, leading to better soil porosity and reduced compaction as a result, soil bulk density decreases [13].

Water holding capacity:

As soil fertility status is strongly related to water availability; regarding the effect of compost and FYM on physical properties of the soils, it is essential to underline that the effect of amendments on soil water content and water holding capacity (WHC). In long-term field experiment application of 10 t ha^{-1} FYM along with 100 % NPK recorded highest water holding capacity[14]. A long term field experiment since 1994-2004 in rainfed upland red laterite soils of dryland agriculture research farm, Phulbani Orisa under rice-horsegram cropping sequesnce FYM treated soil recorded the highest water holding capacity[15]. For each 1- 2 percent increase in soil organic matter, the available water holding capacity in the soil increased by 3.7 percent. When a soil is at field capacity, organic matter has a higher water holding capacity than a smaller volume of mineral soil. While the water held by organic matter at the permanent wilting point is also higher overall, an increase in organic matter increases a soil's ability to store water available for plant use.[16]

Effect of organic manures on soil chemical properties

Nutrient Availability:

Organic materials provide slow-releasing nutrients, enhancing soil fertility and reducing the need for synthetic fertilizers. The organic amendments contain essential nutrients like nitrogen, phosphorus, and potassium, as well as micronutrients like calcium, magnesium, and sulfur. Application of organic manure undergoes decomposition and mineralization processes, releasing nutrients gradually into the soil solution[17]. The slow release of nutrients from organic matter ensures a sustained supply of plant-available nutrients throughout the growing season, supporting crop growth and development. The application of a high rate of biochar, the K content of the whole soybean plant was 28.78 percent higher than that of the control[18]. The increased Zn availability might be attributed to the direct addition of these nutrients by fortified organic manures, which maintain maximum available Zn and Fe status in post-harvest soil. Further the complexation of micronutrients with applied organics might have mobilized and increased the availability of Zn and Fe in soil[19]. The increase in available nitrogen due to organic matter application is also attributable to the greater multiplication of soil microbes caused by the addition of organic materials which mineralize organically bound N to inorganic form[20]. The increase in available phosphorus with FYM application to the contribution of P by the organics to the soil available pool and coating of organic material on sesquioxides which reduces the phosphate fixing capacity of soil.[21,22] Increase in available K due to addition of organic manure may be ascribed to reduction of K fixation and release of K due to interaction of organic matterwith clay[23,24,25].

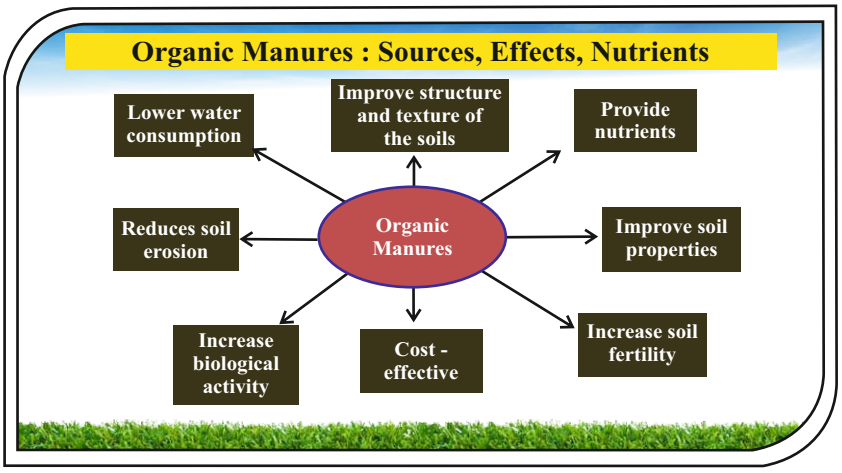
pH & EC : Application of various micronutrients fortified organics brought out a significant reduction in pH and EC of the soil. All the micronutrients fortified organics evaluated contributed for a favourable improvement in the soil physico-chemical properties of soil by way of reduction in soil reaction and salinity. The decrease in soil pH may be attributed to the higher production of CO2 and organic acids on the decomposition of applied organic wastes which favorably reduced the pH of soil. The effect of fortified organic manure with micronutrient and bio active compound in significantly decreasing the EC of soil. The decrease in EC might be due to the production of organic acid during decomposition of FYM in soil. Decreased EC was also due to results of organic matter triggered leaching of excessive ions by improving the physical property of soil[26].

Effect of organic manures on soil microbial properties

Soil microbes are crucial for maintaining soil health and productivity, participating in processes such as nutrient cycling, organic matter decomposition, and suppression of soil-borne pathogens. The addition of organic manures has been shown to increase microbial activity and biomass, thereby enhancing soil fertility [27]. Organic manures differ in their nutrient content and decomposition rates, which influence microbial community structure and functions [28].Microbial biomass carbon (MBC) and nitrogen (MBN) are important indicators of microbial population and activity. Numerous studies have reported increased MBC and MBN with the application of organic manures. For instance, application of FYM significantly increased microbial biomass compared to inorganic fertilizers[29]. Vermicompost, in particular, has been shown to enhance microbial biomass due to its rich organic content and microbial inoculum [30].

Soil enzymes such as dehydrogenase, phosphatase, and urease are closely associated with microbial activity. Organic manures stimulate enzymatic activities by providing energy sources and nutrients to microbes. Compost and green manure have been reported to elevate enzyme activities, enhancing phosphorus and nitrogen availability [31].Organic amendments influence microbial community composition and diversity. Manures rich in organic carbon promote copiotrophic organisms like Proteobacteria, while suppressing oligotrophs [32]. The long-term use of organic inputs increases microbial diversity and functional resilience, improving soil structure and resistance to stress[33]. Figure 2.

Figure 2 : Organic Manures : Sources, Effects, Nutrients



Conclusion:

Organic fortification offers an effective, sustainable means of improving soil health and productivity. By enhancing soil organic matter, microbial activity, and nutrient availability, organic manure contribute to soil fertility and ecosystem health. However, challenges such as cost, inconsistent quality, and labor intensity need to be addressed for broader adoption. Further research into optimizing organic fortification practices and developing cost-effective, high-quality organic amendments will help maximize the benefits of organic fortification for soil health. This review highlights the importance of organic fortification in fostering soil health and its critical role in sustainable agriculture. Sustainable soil management practices that integrate organic manure application are essential for maintaining soil biological properties, supporting soil health, and promoting agricultural sustainability in the face of ongoing global environmental challenges. Further investigation into its integration with modern farming practices could lead to more resilient and productive agroecosystems.

Source of Support: Nil

Conflict of Interest: Nil

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