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Compost Formulation from Different Wastes to Enhance the Soil and Plant Productivity: A Review

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ABSTRACT

Different types and sources of compost are used to increase agricultural productivity. This review reveals different compost formulation methods and the incorporation of those methods into agriculture to reduce waste production, providing a better way to maintain soil fertility for better plant yield. This review furnishes an in-depth update on the impact of prepared compost from different ingredients like municipal waste, kitchen-based food waste, livestock waste, agricultural waste, algae, and industrial waste to find the effects on soil health, plant growth parameters (height, stem diameter, leaf number, chlorophyll content, etc.), and plant yield. Several studies have shown that compost significantly affects the soil's health and improves different plants' morphological (height, width, stem diameter, leaf shape, leaf size, leaf arrangement, root system), physiological (photosynthesis rate, transpiration rate, respiration rate, stomatal conductance, chlorophyll content, carbon dioxide assimilation, nutrient uptake, water use efficiency, flowering time, germination rate), and chemical properties (pH, macronutrient content, micronutrient content, carbohydrate content, protein content, lipid content, phytochemical content, essential oil content, pigment content). Produced compost from different ingredients has significant results for enhancing soil health, nutrient supply to plants, reducing heavy metal accumulation in plants, increasing plant yield, and reducing the environmental pollution. Overall, the results of this study demonstrate the potential of compost formulations made from different waste materials to enhance soil fertility and plant productivity. These findings have important implications for sustainable agriculture and waste management practices. Using compost as a soil amendment can help reduce waste and improve soil health, increasing plant yields and reducing the need for chemical fertilisers. However, the dose of compost prepared from various wastes in different climatic conditions should be optimized at the farm level, with particular emphasis on economic sustainability.

Keywords: Food waste; Industrial waste; Municipal waste; Plant growth; Plant yield; Soil health

NOMENCLATURE

%	Percentage
@	At the rate
↑	Increased
cm	Centimetre
et al.	Et alia
g/L	Grams per litre
kg/ha	Kilogram per hectare
N	Nitrogen
NH_4^+	Ammonium
NO_3	Nitrate
P	Phosphorus
t/ha	Tonne per hectare

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1. INTRODUCTION

With an ever-growing population, the demand for food security has risen, prompting us to develop new methods or techniques for improving the output and growth of various crops and plants. Chemical fertilisers, insecticides, and herbicides were introduced to boost production and growth. Initially, they aided in the increase of yield and the provision of food security. However, as time passed, they began to accumulate in soil and plant components, from which they began to move up the food chain. Yields initially grew as fertiliser use increased but later began to decline.[1] Excessive fertiliser use affected soil structure in physical, chemical, and biological ways, resulting in this. Every year, the yield rises as soil fertility falls, resulting in a reduction in soil nutrition. The number of microorganisms also fell, resulting in a decrease in biological activity. The soil contains these biological processes and organic materials. The loss of organic matter in soil reduces the capacity of the soil to hold water. This causes more water to be leached from the surface to the ground. This puts further strain on water supplies.[2] The problem of trash disposal is the world's second challenge today. Every process produces a considerable amount of waste around the globe. This waste can be in the form of solid, liquid, or gaseous materials produced as a by-product of the main process. The industrial waste includes chemicals, metals, plastics, and other materials generated during manufacturing. Agricultural waste can include crop residue, manure, and other by-products of farming activities. Domestic waste includes household garbage, wastewater, and other materials generated in homes. The generation of waste can negatively impact the environment, including soil and water pollution, air pollution, and greenhouse gas emissions. Proper management and disposal of waste are crucial to minimise these negative impacts and ensure a sustainable future for our planet. This is where composting comes in as a sustainable method of waste management that can help reduce the amount of waste sent to landfills and provide a valuable resource for enhancing soil and plant productivity.

Meanwhile, crop residues, plant leaves, animal waste, chicken waste, and farm yard waste are all natural organic and biodegradable wastes. These biodegradable items can also be used to make compost, which solves two problems: garbage disposal and soil conditioner. Composting manure from animal farms and sewage waste might result in organic fertilisers.[3] Compost improves the soil's physical, chemical, and physical qualities by adding nutrients.[3,4] *Composting* is a natural process used for centuries to recycle organic waste materials into a valuable soil amendment. It involves decomposing organic matter by microorganisms, resulting in a nutrient-rich material that can be added to soil to improve its fertility, structure, and water-holding capacity. Composting is an environmentally friendly and sustainable method of waste management, and it can help to reduce greenhouse gas emissions from landfills. Different methods are used to make different types of compost, and different substrates can be used to make compost. Many studies have been conducted to determine the organic additives such as vermicomposting of algal waste, animal waste compost; agricultural waste compost, municipal waste compost, and temple waste compost alter soil characteristics, plant growth parameters, and yield parameters over time. By understanding the benefits of composting and the different types of organic waste materials used to formulate compost, individuals, and organizations can reduce their environmental impact and enhance the productivity of their gardens, farms, and landscapes.

Therefore, this article reviews the best approach to boost crop development and production after applying compost prepared from other waste. This article focuses on how waste materials can be disposed of so that they can be put to good use in the agriculture sector rather than causing environmental harm.

2. COMPOST AND SUSTAINABLE AGRICULTURE

Sustainable farming is a solution to the problem of modern society's food production, or, in other words, chemical farming. Applying compost lowers the cost of inputs and raises the growers' income. However, there is a need to include composting in the agricultural pattern for sustainable agricultural development because much waste is generated during agricultural practices, such as farm yard waste, crop residue, and animal waste, which can be a considerable nuisance. It can all be incorporated and used as a beneficial product like compost. It has the potential to lower farming costs while also increasing productivity. It takes care of our trash management issues. Composting can assist in preserving soil fertility, controlling erosion, and increasing overall soil health. Composting can help eliminate weeds and diseases, reduce the usage of weedicides and pesticides, and reduce the bioaccumulation of toxic chemicals in the food chain. As a result, this is helpful in two ways: socially, safer food for the community, and economically, less agricultural inputs and higher yields, increasing the farmer's overall income.[5–7]

Composting improves soil structure and consequently encourages the formation of healthy root systems in plants, allowing for more remarkable growth. Compost application darkens the color of the soil, allowing for improved light and heat absorption and preventing temperature changes in the soil.[8-9] The addition of compost to the soil allows it to hold more nutrients.[10] Composting provides nourishment for beneficial bacteria and earthworms while also promoting their growth.[11,12]

Therefore, composting is a superior answer to the existing waste disposal dilemma. Organically cultivated commodities now command higher prices, increasing a farmer's income. Composting and using it can help farmers save money by lowering operating costs. Waste disposal can be avoided with the help of social composting. It has the potential to reduce the use of landfills and incineration, both of which are costly waste disposal options. However, it improves soil fertility, which reduces the need for water, pesticides, and herbicides, resulting in cost savings. It conserves water, maintains soil temperature stability, suppresses weed development, feeds crops, and prevents soil erosion.[10,13,14]

3. METHODS OF COMPOSTING

Composting is the natural process of microorganisms decomposing organic materials in natural settings. Crop leftovers, animal waste, municipal solid waste, industrial waste, sewage waste, and food remains are all biodegradable items that can be composted and utilized as fertiliser.[13–16] Compost is a rich source of nutrients such as organic matter and other micro and macro nutrients necessary for plant growth. This aids in improving soil fertility, making it a viable agricultural alternative to artificial fertilisers. It has a high plant nutrient concentration and improves the soil's physical, chemical, and biological qualities.[17–19]

Table 1. Details of different industrial compost applied on different plants for higher yield

S. No.	Compost name	Composition of compost	Plants/vegetables name	Reference
1.	Filter cake	pH-8.0, EC-1.70 µs/m, OM-36.2%, N-1.77 %, available P-1.62 mg/kg, available S-1.62 mg/kg, K-0.16%, Ca-1.3%, Mg-0.31%, Fe-3 mg/kg, Mn-39 mg/kg, Cu-1.24 mg/kg, Zn-31.00 mg/kg	*Triticum turgidum L.var. durum*	20
2.	Liquid organic fertilizer	pH-4.5–7.8, EC-25–33 µs/m, total N-0.14–0.33%, total P_2O_5-0.002–0.017%, total K_2O-0.881–11.8%, OM-0.26–3.25%, OC-0.26–3.20%, and C:N ratio-6.14–17.92	Green Cos Lettuce	21
3.	Compost of textile sludge	pH-6.7, moisture content-80%, TOC-35%, TN-0.47%, nitrate-nitrogen-2532.9 mg/kg, total P-0.63%, S-0.001%, Na-3634.1±0.9 mg/kg, and K-4066±4.1 mg/kg	Amaranthus gangeticus	22
4.	Municipal solid waste compost	pH-7.3, total N-13.2 g/kg, mineral N-2.18 g/kg, OM-41.85%, Na-28.3 mg/kg, K-334.1 mg/kg, Ca-26.8 mg/kg, Cd-2.23 mg/kg, Pb-5.08 mg/kg	Rice	25
5.	Bio solid fertilizer	pH-6.4, EC-8.5 ds/m, OM-48%, NT-240 mg/kg, P-3400 mg/kg, K-3,100 mg/kg, Fe-3425 mg/kg, Mn-76 mg/kg	Zia Mays	26
6.	Bio solid and sugarcane falter cake	Biosoild: pH- 7.60, OC-19.80%, Na-0.79%, P_2O_5-2.23%, K_2O-0.24%, C/Na-25% Sugarcane falter cake: pH-6.8, OC-23.49%, Na-0.61, P_2O_5- 0.95, K_2O- 0.30, C/N-38	Soybean	28
7.	Compost from municipal solid waste and poultry manure	pH-7.87±0.24, CE-8.8±0.2 ds/m, TOC-50.4±3.1%, total N-3.85±0.15%, NH_4^+-0.055±0.0%, NO_3^--0.09±0.02%, MgO-1.78±0.21%, CaO-7.13±0.62%, K_2O-10.5±0.7%, P_2O_5-8.39±1.4%, Fe-0.31±0.07%	Tomato plants	29

4. DIFFERENT COMPOSTS AND THEIR APPLICATION IN AGRICULTURE

4.1 Industrial Waste Compost

Gonfa[20], *et al.* applied bagasse ash and filter cake amendments to study the production of wheat (Triticum turgidum L.var. durum). The composition of filter cake and bagasse ash was slightly different from each other. Application of filter cake (100 *t/ha*) showed significantly higher plant growth parameters like plant height (75.0 *cm*), tillers (2.7 number), spike length (4.4 *cm*), spikelet per spike (8.8 number), and kernels per spike (17.2 number). Other studies reported that compost prepared from liquid organic fertiliser, liquid chemical fertiliser, biosolid fertiliser, textile and industrial sludge, sugar mill effluents, municipal solid waste, sewage waste water, biosolid and sugarcane filter cake, poultry manure had increased soil health, followed by the production of different plants like Green Cos Lettuce, rice, Amaranthus gangeticus, Triticum aestivum L., tomato plants, sorghum, sunflower, Zia mays, Pennisetum glaucum L, palm trees, soybean, etc. (Table 1).[21-31]

4.2 Domestic Waste Compost

Oliveira[32], *et al.* worked by applying almond shell substrate to *Phaseolus vulgaris* L. (cv. Saxa) to find the changes in growth, physiological and biochemical properties. The highest growth and significant physiological and biochemical changes were seen in the shell mulch (SM) treated plot. Oladele, *et al.*[33] worked with rice growth (*Oryza sativa*) in biochar. The application of biochar (pH-8.50, total organic carbon-51.13 %, total N-0.30 *g/kg*, P-0.73 *mg/kg*, K-9.20 *cmol/kg*, Ca-1.25 *cmol/kg*, Mg-4.50 *cmol/kg*, Na-0.95 *cmol/kg*, CEC-16.00 *cmol/kg*, Cu-226.5 *mg/kg*, Fe-4.80 %, Zn-561.5 *mg/kg*, Mn-332 *mg/kg*) at a rate of 6 t/ha produced the highest values of grain yield (3674.16 *kg/ha*), straw yield (4220 *kg/ha*), and harvest index (0.46). Different growth parameters of cabbage, cauliflower, and radish were studied by Kumari[34], *et al.* with the application of food waste compost (pH-9.3, EC-9.24 *µs/cm*, TDS-13.00 *mg/L*, WHC-19.84 %, SM-17.78 %, SOM-97.16 %, total N-1.68±0.04 *kg/ha*, K-176.07±12.02 *kg/ha*, P-28.33±2.79 *kg/ha*). Study found a significant improvement in plant morphology and yield in food waste treatment plots.

4.3 Agricultural Waste Compost

Agricultural wastes have the great potency to be recycled to improve soil quality enrichment, like soil organic carbon, nutrient profile, bulk density, soil porosity, etc. It has been found that the application of sheep manure[35], grapefruit waste[36], spent Agaricus subrufescens mushroom compost[37,38], olive tree waste[37], tomato waste compost[39], turkey litter compost[39], licorice compost[39], palm compost[40-41], slaughterhouse waste[42], fisheries manure[42], cow manure[43], sugarcane press mud[44], peach palm compost[45], water hyacinth[46], coconut choir compost[46] has a significant effect for higher soil fertility as well as plant productivity. The study found that the quality of plants was also increased with a higher quality of antioxidant and anti-cancerous molecules after treatment of compost prepared from agricultural waste compost.

4.4 Vermicompost

The compost is prepared from different waste products after applying different worm species, especially earthworms like *Eisenia foetida* and *Lumbricus rubellis*. It has been found that using worms increases soil fertility more than any other composting process due to the addition of body secretion and the metabolic waste of earthworm species. Many studies reported that vermicomposting of rice husk ash[47], coconut fibre[47], manure[48], solid municipal waste[49], leaf vermicompost[50], vermifiltared water from waste water[51], vermiwash prepared from *Eisenia foetida* culture[52], cow dung vermicompost[53], rubber leaf vermicompost[54], tannery wastes[55], macrophyte prepared vermicompost[56] has significantly increased the stem diameter, plant height, leaf number, shoot fresh weight, root length, dry weight, chlorophyll a+b, seed germination rate, grain weight/plant, fresh root weights, fruit quality characteristics (pH, total soluble solid, titratable acidity, Vitamin C, etc.) of different plants after increasing the soil nutrient profile.

4.5 Livestock Waste Compost

Sikder & Joardar[57] investigated the effects of poultry litter and poultry litter biochar on Gima kalmi (Ipomoea aquatica). Applying poultry litter biochar (@4.0 t/ha) produced higher plant growth. Ebrahimi, *et al.*[58] studied the growth parameters of tomatoes (Lycopersicon esculentum L.) using cow manure, household compost, and spent mushroom compost. The study reported that applying this compost increased the soil fertility and the yield of tomatoes. In a hydroponic system, Tikasz, *et al.*[59] studied Romaine lettuce (Lactuca sativa var. longifolia) and Russian kale (Brassica napus var. "Red Russian") using aerated chicken, cow, and turkey manure. The highest lettuce yield was found in turkey manure extract at 50 *g/L*. Chicken manure had detrimental effects on the growth parameters of both lettuce and kale. Joardar and Rahman[60] studied the growth of Ipomoea aquatic (water spinach) after the poultry feather waste treatment. The plant height and fresh and dry weight were higher in the treated group. El-Zeadani, *et al.*[61] reported wheat germination in raw poultry and digested poultry manure. The length and dry mass of plumule decreased in raw poultry manure, but it increased in digested poultry manure.

4.6 Algal Compost

In a study conducted by Ramya[62], *et al.*, they examined the growth of *Solanum melongena* after the application of compost prepared from brown algae (*Stoechospermum marginatum*). All growth, biochemical, and yield parameters were higher in 1.5 % of treatments, and higher doses harmed all parameters. Mahboub Khomami[63], *et al.* worked on *Dieffenbachia amoena* by application of peanut shell and Azolla-prepared compost. The most promising results were found in the Azolla compost treatment after mixing with 30 % peanut shells. Kreider[64], *et al.* worked on applying duckweed-prepared compost and found a higher yield in the treated plot. Other studies also indicated that algal compost significantly impacts plant growth and yield (Table 2).

4.7 Temple Waste Compost

Singh[68], *et al.* prepared vermicomposts using floral waste from temples to apply on chickpeas (Cicer arietinum cv. Radhey). The best growth results were found by applying 120-day-old vermicompost @ 12 %. Jahagirdar[69], *et al.* reported that the compost of flora has an excellent level of organic carbon (90 %). Therefore, applying this compost may increase the yield in the agriculture sector. Sharma[70], *et al.* also reported that floral waste is highly enriched with micronutrients. They reported that applying sawdust and cow dung during the floral compost preparation enhanced the compost quality. Kumari[71], *et al.* reported that flower compost has significant total nitrogen and organic carbon. Tiwari and Juneja[72] prepared compost from marigold flowers after being mixed up with cow dung. Eisenia foetida was used in this study. It was reported that the mixing in the 60:40 proportion of marigold flower and cow dung has a higher bioconversion rate. Therefore, all these studies indicated that the prepared compost from floral waste has excellent potency to increase plant yield.

Table 2. Some research findings on the effects of algal compost on soil and plants

S. No.	Algae name	Composition of compost and effects	Reference
1.	Arthrospira platensis, Chlorella sp., Palmaria palmate, Laminaria digitata, Ascophyllum nodosum	Total nitrogen↑, soil accessible phosphorus↑, nitrate↑, inorganic NH4+ and NO3↑, inorganic nitrogen concentrations↑	65
2.	Acutodesmus dimorphus	Lateral root of tomato plant↑, flower bud↑, branches↑, fresh plant weight↑	66
3.	Oedogonium intermedium and sugarcane bagasse	Soil N and P↑, sweet corn (Zea mays) yiled↑	67

Note: ↑ means increased

5. REASON BEHIND THE HIGHER YIELD OF CROPS AFTER COMPOST APPLICATION

Applying compost derived from temple waste, algal waste, livestock waste, vermicompost, agricultural waste, domestic waste, and industrial waste can lead to higher crop yields. Compost is rich in essential nutrients such as nitrogen, phosphorus, and potassium, which are required for plant growth. When compost is added to soil, these nutrients become available to the plants, resulting in improved growth and higher yields. However, compost is a rich organic matter source, improving soil structure and texture. This helps improve water retention and aeration, which are important for plant growth.

Meanwhile, compost contains beneficial microorganisms that can help break down organic matter and release nutrients. These microorganisms also help in improving soil health and suppressing plant diseases. However, compost can help to balance the pH of the soil, making it more suitable for plant growth. This is especially important in soils that are too acidic or too alkaline. Compost can help to reduce soil erosion by increasing the ability of the soil to hold water and nutrients. Overall, all the reviewed articles reveal that applying compost can improve soil health, increase crop yields, and promote sustainable agriculture practices.

6. SIGNIFICANCE OF THIS STUDY

This review enlightens the most recent ways to reduce, reuse, and recycle different waste materials like municipal waste, kitchen-based food waste, livestock waste, agricultural waste, algae, temple waste, industrial waste, etc. The compost from different ingredients has the potency to enhance soil health and nutrient supply to plants, reduce heavy metals accumulation in plants, increase plant yield, and reduce environmental pollution (Fig. 1). The dose of the prepared compost from various wastes in different climatic condition should be optimized at farm level with particular emphasis on the economic sustainability. Ultimately, many research avenues may start with composting techniques and improvising different composting strategies for better soil health and plant yield in different geographical regions.

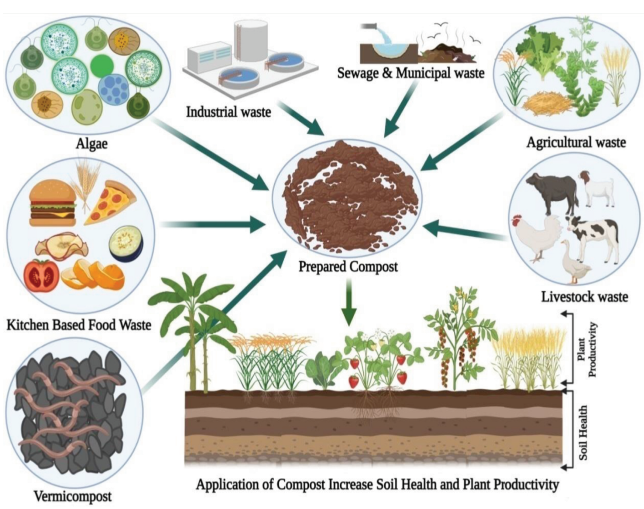

Figure 1. Prepared compost from different ingredients can enhance soil health and nutrient supply to plants, reducing heavy metals accumulation in plants and increasing plant yield.

7. CONCLUSION

According to this review, compost made from various ingredients has significant growth and yield results for all the crops evaluated. The addition of compost, even in tiny amounts, had a significant impact. In a few cases, the greater compost doses also had a negative impact. However, compost enhanced the soil's water-holding capacity, plant nutrition, nitrogen, and other critical micronutrients. Due to the presence of various organic acids and growth stimulants created by the organic decomposition of complex compounds in substrates, compost significantly promotes seed germination. The use of compost also reduced heavy metal accumulation in plant sections. This enhancement aided plant development in locations where water was scarce. All composts were made from waste materials, allowing for more efficient waste disposal and an alternative to artificial fertilisers in agriculture. These organic additives are inexpensive and can be made from waste on farms. They produce considerable benefits and can be used to substitute expensive chemical fertilisers, improving farmers' conditions by lowering investment and increasing production. However, the dose of compost prepared from different wastes in different climatic conditions should be optimized at the farm level, with particular emphasis on economic sustainability.

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