Utilization of organic fertilisers a potential approaches for agronomic crops: A review

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ABSTRACT

Organic fertilisers are of biological origin and the amount of nutrients they produce varies greatly. Besides providing the essential macro and micro nutrients, they also provide an array of plant growth-promoting substances. Organic agronomy is a relatively recent technique of farming in developed countries. While several studies were conducted on the impact of organic fertilisers on soil properties and crop production, further research is needed to determine comparative results between organic fertilisers. This paper aims to review some of the influences and impacts of poultry manure, cow dung, goat manure, vermicomposter and seaweed extracts. Much-needed characteristics of numerous crops were enhanced with the appropriate application of these organic fertilisers. Organic fertilizer applications influence the increase of plant heights, vegetative growth, yields and yield attributes. The application of adequate fertilisers also influences the qualitative parameters and post-harvest traits of most crops. Selecting the best organic fertilisers at an optimal application rate that could be the best source of nutrient supplement in cultivating qualitative crops, is a gap that needs to bridge. Therefore, different application rates of the above organic fertilisers were also studied.

Introduction

Organic fertilisers increase the yield and quality of crops when used appropriately. Nitrogen (N), phosphorus (P₂O₅), potassium (K₂O), sulfur (S), copper (Cu), calcium (CaO), manganese (Mn), magnesium (MgO), boron (B) and iron (Fe), zinc (Zn) may be a valuable source of crop nutrients, animal manure provides much of the nutrients that crops need (1). An important difference between animal manure and conventional synthetic fertilisers is that some organic nutrients in manure tend to take some time to decomposition (mineralization) and be transferred to organic form available for plant uptake. Fertilisers from animal products are slower in supply of plant nutrients than synthetic fertilisers (2). Organic fertilisers offer significant improvements in crop growth and yield, there serve as nutrient reservoir during mineralization and humification, macro and micro nutrients are released to provide the essential elements for plant growth (3). To reliably increase the yields of horticultural crops such as eggplants (Solanum melongena), peppers (Capsicum annum L.) and tomatoes (Lycopersicon esculentum), the application of organic fertilisers has been reported (4). As observed in organic fertilisers, nitrogen availability affects vegetative improvement and promises significant and vigorous growth (5).

Effects of poultry manure on crops

There is a global organic farming trend; poultry manure as an inorganic fertiliser alternative would help achieve this target (6). The poultry manure was abundant in nutrients (Supplementary Table 1), which influences agronomic crops and ensures safe and vigorous growth. To reliably improve the yields of horticultural crops such as potato (Solanum tuberosum) (7), maize (Zea mays) (8) and tomato (L. esculentum) (9), the application of poultry manure has been promising. Poultry manure had a positive impact on growth and as well as yield of pumpkin (Telfairia occidentalis). This may be attributed to the fact that poultry fertiliser contained important nutrient...
components linked to elevate the photosynthetic activities of crops which encourages root and vegetative development (10).

The highest yields of pepper (C. annuum) were achieved with the application of poultry manure at 5 t/ha (5). A study observed that tomato (L. esculentum) dry matter content, yield and soil nutrients absorption were substantially improved by poultry manure (12). Applying 25 t/ha of poultry manure is recommended for optimizing tomato fruit yield, increasing of poultry manure application to 50 t/ha of manure did not result into fruit yield as compared with the 25 t/ha of poultry manure. This could be so because of the dilution impact of excess organic matter and high nitrogen supply (13). High nitrogen concentration decreased calcium in leaves of tomato crops and increased tomato fruit blossom-end rot in Guyana (14).

Due to an increased N application, an improvement in the number of fruits and fruit size of tomato plant was observed (15). Poultry manure has significant effects on the plant's vegetative growth and ensures stable and robust production (5). There was an increase in growth with increased rates of poultry fertiliser (16). Application with an increase in poultry fertiliser rates, yield increases indicating that poultry manure provides nutrients that promote vigorous plant growth, culminating in an increase in fruit yield (6). In order to increase eggplant's yield, the use of poultry manure which is a major source nitrogen was applied to the crop at the rate of 30 t/ha (16). Relative to other manures, poultry manure contains higher nitrogen and phosphorus (17), while poultry droppings provides phosphorus more quickly than other organic waste (18). Studies have shown that poultry manure application rates at 4 t/ha – 30 t/ha was found be effective depending on the target crop (Supplementary Table 2).

Effects of cow dung on crops

Cow dung manure is a composted form of cattle dung with agricultural residue. It improves the soil nutrients, tilth, aeration and water holding capacity (33). Cow manure slowly and gradually releases nutrients, tilth, aeration and water holding capacity with agricultural residue. It improves the soil components linked to elevate the photosynthetic activities of crops which encourages root and vegetative development (10).

The presence of humic acid and micro and macro nutrients in vermicompost (55) in vermicompost fertilisers (Supplementary Table 5) influences plant growth and development treated with the compost. The maximal increase in the plant height of Matricaria chamomilla (56) was detected when plant was treated with vermicompost. Compared with the control when cultivated in vermicompost modified peat moss supplemented with different mycorrhiza concentrations, the plant height of the maize (Zea mays) (57) increased significantly. The highest potato (S. tuberosum) plant height was observed when vermicompost was added to the soil with 100% NPK (chemical fertilisers) (58). Compared to untreated (sole soil), perithecium weed prepared vermicompostimproved the plant height of Okra and the soil improved with the prescribed amount of inorganic fertilisers (59). There was an increase in the plant height of Crossandra (Crossandra undulataefolia) in plots treated vermicompost as opposed to the control plots (60). Vermicompost application increased eggplant (S. melongena) plant height (61). Greenhouse spinach treated vermicompost produces the high value in plant height and number of leaves in treatment with highest application rates (62).

It was reported that, vermicompost treatments significantly increased plant height relative to control treatments, no substantial difference between vermicompost treatments and chemical fertilisers treatment was observed (64). The average plant height of the Amarathus species increased with the application of vermicompost. The average plant height and number of branches had a higher values than control and treatment with inorganic fertiliser application after 30 days of germination. A study on vermicompost, cowdung, vermiwash and inorganic fertilisers application on okra (Abelmoschus esculentus), reveals that vermiwash and vermicompost had great influence on the growth and yield of okra (65). Additionally in several studies it was reported that, application of vermicompost gave a significant yield in A. esculentus (66), strawberry (Fragaria x ananassa) yields (67), fruit yield of eggplant (Solanum melongena L.) (61). Moreso, treatments with vermicompost influences potato (Solanum tuberosum) production yield (58), total yield of cucumber (C. sativus) (68), harvest index in Crossandra (C. undulataefolia) (60), higher tomato (L. esculentum) yield (55), Geranium oil yields in cucumber (Cucumis sativus). Similarly, it was recorded that highest weight of plant and yield per hectare in cucumber, with the application of 10 t/ha farnyard manure and 400 kg/ha of chemical fertilisers (42). In addition to the application of farnyard manure, soil enrichment with organic matter through cow dung manure substantially improved tuberous root yield components of sweet potato (Ipomoea batatas) (43). There is a significant increase in the yield of different vegetable crops (44) and other agronomic crops with differences in the application rates of cowdung ( Supplementary Table 4). Combined application of neem cake and cow dung increased the tomato yield (45).

Effects of vermicompost on crop growth

The presence of humic acid and micro and macro nutrients (55) in vermicompost fertilisers (Supplementary Table 5) influences plant growth and development treated with the compost. The maximal increase in the plant height of Matricaria chamomilla (56) was detected when plant was treated with vermicompost. Compared with the control when cultivated in vermicompost modified peat moss supplemented with different mycorrhiza concentrations, the plant height of the maize (Zea mays) (57) increased significantly. The highest potato (S. tuberosum) plant height was observed when vermicompost was added to the soil with 100% NPK (chemical fertilisers) (58). Compared to untreated (sole soil), perithecium weed prepared vermicompostimproved the plant height of Okra and the soil improved with the prescribed amount of inorganic fertilisers (59). There was an increase in the plant height of Crossandra (Crossandra undulataefolia) in plots treated vermicompost as opposed to the control plots (60). Vermicompost application increased eggplant (S. melongena) plant height (61). Greenhouse spinach treated vermicompost produces the high value in plant height and number of leaves in treatment with highest application rates (62).
**Pelargonium species** (69) and *Matricaria chamomilla* (56). Several studies in Supplementary Table 6 shows the effects of vermicompost application rates on crops.

**Effects of goat dung on crop growth**

Like other animal manures, goat manure has essential elements (Supplementary Table 7) required for plant growth including nitrogen, though such composition may vary geographically depending on the diet that goats feed on (81). Compared to other animal manures, goat manure has been shown to release high concentrations of plant required nutrients more than cattle manure, horse manure and others for except poultry manure (82). Even though animal manure varies in nitrogen content due to the type of feed given to animals, generally total nitrogen content in goat manure, for example, is about 2-3% of dry weight manure. The total nitrogen requires to be processed to get plant-available nitrogen (nitrate, ammonium), of which mineralizable nitrogen is about 20% of total nitrogen (83).

Goat manure can be treated before being added to the soil, in soil-based agriculture, or applied directly to the soil so that microorganisms in the soil will break the manure naturally in the soil. This is because, the transfer of nutrients from organic to inorganic (plant-available) particularly the nitrogen becomes available through mineralization. The availability of phosphorus from manure is also high in addition to nitrogen (more than 70%) since much of the P is inorganic and readily accessible (81). Nitrogen mineralization is related to the ease with which microorganisms break down the carbon in the manures. Nitrogen available from manures depends on the nitrogen content and the stability of the nitrogen or the ease with which it is mineralized. Aged manures lose nitrogen by volatilization of ammonia; the remaining nitrogen is more stable or resistant to mineralization (84). Therefore, it is advisable to work with manure that is not too aged or composted since the composting process produces lower nitrogen from goat manure, therefore, spreading the manure and combining it with the soil as soon as possible is the perfect manure management to maximize nitrogen supply. The longer the time between production and incorporation, the lower the available nitrogen (84).

Goat manure world-wide has been applied directly to the soil where it was processed to avail plant required nutrients (86). For example, In Sri Lanka, the direct addition of goat manure to the soil for coconut plantation resulted in the supply of sufficient plant nutrients needed for the coconut plantation such that there was a significant increase in nut yield (87). In an organically managed field trial, in the United States of America, it was observed that in a raw dairy goat manure treatment, the yield of corn was still higher over a three-year cycle relative to a compost of dairy goat manure and leaves (88). Elsewhere in Kenya, goat manure applied directly to the soil helped provide nutrients (89), and helped reduce soil acidity, which inturn aids in crop production (90). Goat manure was effective at applying 5 t/ha to high dose of 40 t/ha (Supplementary Table 8).

**Effects of seaweeds on crop growth**

An important part of coastal marine habitats is marine algae. These include the macroscopic, multicellular marine algae usually found in the world’s oceans costal areas where there are appropriate substrates. On the rocky shores of the temperate regions, brown seaweeds are the second most common group of about 2000 species that surpass their maximum biomass levels. They are the type most widely used in agriculture (96), and *Ascosiphon nodosum* (Brown seaweed) (97) is the most researched among them, due to its high mineral composition (Supplementary Table 9). Besides *A. nodosum*, other brown algae include, *Turbinaria spp, Sargassum spp. Laminaria spp. and Fucus spp.* In agriculture, they are used as biostimulants (98). The benefits of seaweeds as a source of organic manure and fertilisers have contributed to soil modification for years (99).

Nearly 15 metric tons of seaweed’s fertilisers are produced yearly (100), of which a large proportion is used to improve crop growth and yield as nutritional enhancements and as biostimulants or biofertilisers. For use in agriculture and horticulture, a range of commercial seaweed extract products are available. The application of seaweed extract has a wide range of beneficial effects on plants, such as early germination and seed establishment, improved crop production and yield, increased resistance to biotic and abiotic stress, and increased post-harvest qualities of crops (101).

Different beneficial effects of both extracts and suspensions of marine brown algae are used in agronomy and agriculture (103). Algal extracts increase seed germination, boost plant growth, yield, flower set and development of fruit and post-harvest shelf life as plant growth biostimulants (104).

Results of marigold experiments show that, vegetative growth was increased by using seaweed extract (105). The improvement in seaweed treated crops growth could be attributed to the presence of macro and micronutrients and some growth-promoting compounds in the extract of seaweed (103). Kentucky bluegrass (106), tall fescue and creeping bentgrass have also been shown to increase antioxidant status through exogenous application of seaweed extract (107). Seaweed extracts collected from *Ecklonia maxima* have increased the amount of vegetables per plant when added to soil drench as fertiliser in lettuce leaf (108) and wheat (109). Seaweeds have growth-enhancing ability this may be due to the presence of macro and micro nutrients available in seaweeds (110). Application to soils or tomato foliage a low concentration of *A. nodosum* extract produces a higher chlorophyll level than untreated controls (111). The fresh weight of green gram seedlings tested with seaweed extracts steadily increased the growth of *Vigna unguiculata* promoted by increasing concentration of seaweed extract from *Ulva lactuca* (112), similar effects were also reported in red gram (113), in cowpea (114) and green gram,
which reported linear growth of both shoots and roots. In various plant systems, effects of *A. nodosum* have been identified, including the increase of plant growth (115).

**Conclusion and prospects of organic fertilisers**

In conclusion, organic fertilisers response has a significant role in the growth and yield parameter of different tested crops. Organic fertilisers are widely applied in crop production, and they are proper substitutions for chemical fertilisers. Application of bio-fertiliser significantly improved quality and quantity features in agronomic crops. Organic farming is not necessarily non-chemical agriculture, but it is a method that combines soil, plant and water relationships. Organic agriculture contributes to soil conservation, fair energy exchange in soil, seeds, water environment processes, maintains the ecological life cycle intact and helps retain massive yield levels. The application of organic fertilisers at appropriate rates gives the maximum yield of crops. In contrast to synthetic fertilisers, organic fertilisers significantly impact plant height, fresh flower weight, branch number, increase soil property and microbial activity in the soil and a long lasting supply of macro and micro nutrients.

As organic farming continues to expand globally, to support the yield and growth of organic crops as a whole, organic fertilisers such as farmyard manures are required. Improving the current technology to increase fertiliser production in terms of nutrients supply and use of locally available organic resources is the future of organic farming. Because of its high price relative to synthetic fertiliser, farmers current use of organic fertilizer is still poor. There are also some challenges to the use of organic fertilisers that are not overcome: for example, a lack of expertise and experience in the use of organic fertilising; poor capacity to respond on unpredicted external factors such as drought, sudden emergence of new diseases and pests and high certification costs amongst others (116).

Therefore, more research is required to resolve the concerns of farmers. For example, creative and efficient agricultural services programmes could be introduced to inform and support farmers in organic mechanics to resolve the inadequate expertise and experience in the management of an organic farming system (117). The studies mentioned in the article identified the use of several organic fertilisers. These systems have proved successful and can improve farmers profitability. The lack of economic analysis on these organic fertilisers leads to the recommendation of more studies or long-term evaluation of the economic viability of these organic fertilisers.

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**Authors’ contributions**

All authors contributed equally for the development of this manuscript.

**Conflict of interests**

The authors declares no conflict of interest.

**Supplementary files**

Table 1 | Table 2 | Table 3 | Table 4 | Table 5 | Table 6 | Table 7 | Table 8 | Table 9

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