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Effect of Organic Manures and Biofertilizer on Plant Growth, Yield and Quality of Horticultural Crop: A Review

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Abstract
In the development and implementation of sustainable agriculture techniques, bio-fertilization is of great importance in order to alleviate deterioration of natural and environmental pollution. There is an increasing need for the management of the traditional processes of nutrient management, to result in higher nutrient concentration in soil and also to reduce environmental pollution. A considerable number of bacterial species are able to exert a beneficial effect on plant growth. Bio-fertilizers combined with organic manure influences the plant growth by enhancing root biomass; total root surface facilitates higher absorption of nutrients and increase in yield by reducing consumption of natural sources of energy. The organic fertilizers have proved that their application has the potential to increase the biomass and productivity of a wide range of crops. Hence, the research findings pertaining to these aspects on horticultural crops have been reviewed.

Keywords: Farmyard Manure, Vermicompost Forest Litter, Biofertilizers, *Azotobacter*, Phosphate Solublizing Bacteria

Introduction
Recently, there has been a resurgence of interest in environmental friendly sustainable agricultural practices. In the development and implementation of sustainable agriculture techniques, bio-fertilization is of great importance in order to alleviate deterioration of natural and environmental pollution. A considerable number of bacterial species are able to exert a beneficial effect on plant growth. Such bacteria are generally designated as PGPR (plant growth-promoting rhizobacteria). The beneficial effects of these rhizobacteria on plant growth can be direct or indirect. Several mechanisms by which PGPR can act beneficially on plant growth are described. With activities secretion of growth hormones including (a) biofertilization, (b) stimulation of root growth, (c) rhizoremediation, and (d) plant stress control. Organic fertilization is very important in organic fruit production due to use of in-organic fertilizers is not possible. Therefore N2 fixing and phosphate solubilising bacteria, including *Bacillus* sp., *Azotobacter* sp., *Azospirillum* sp., *Beijernckia* sp., *Pseudomonas* sp. are widely used in organic plant growing. Organic farming is a new agricultural production system involves locally and naturally available organic materials or agro inputs to meet out the production system without endangering our precious natural resources. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. The use of organic manures viz. farmyard manure, vermicompost forest litter and biofertilizers viz. *Azotobacter*, Phosphate solublizing bacteria reduce the cost of cultivation and supplement the secondary and micronutrients to crops. Bio-fertilizers combined with organic manure influences the plant growth by enhancing root biomass; total root surface facilitates higher absorption of nutrients and increase in yield by reducing consumption of natural sources of energy. The organic fertilizers have proved that their application has the potential to increase the biomass and productivity of a wide range of crops.

A. Effect of Organic Manures on Plant Growth, Yield and Quality of Horticultural crops

a. Effect of Farmyard Manure on Plant Growth, Yield and Quality of Horticultural crops

Farmyard manure occupies an important position among bulky organic manures. The FYM seems to act directly by increasing crop yield either by acceleration of respiratory process by cell permeability or by hormone growth action. It supplies N, P and K in available forms to plants through biological decomposition.
Mahadeen (2009) [18] reported higher fruit yield (27.62 t ha-1) of strawberry by application of 40 tonnes of organic fertilizer (FYM) + 60 kg ha-1 NPK fertilizers, while the lowest strawberry yield (21.76 t ha-1) was obtained in untreated plot. Lakpale *et al.* (2003) [16] observed the maximum number of branches per plant and pod yield of pea with the application of FYM @ 2.5 t ha-1 in comparison to no FYM application. Rosati (2005) [22] reported application of large amount of organic manure may beneficial in improving soil parameters but in the presence of soil pathogen it is likely to cause them to proliferate. Rana *et al*. (2007) [20] reported that effect of inorganic fertilizer and FYM on French bean and observed that FYM @ 10 t ha1 resulted in significant increase in plant height, pods/plant, seeds/pod, seed and haulm yields.

b. Effect of Vermicompost on Plant Growth, Yield and Quality of Horticultural crops

Vermicompost is stable granular organic matter, when added to clay soils loosen the soil, provides the passage for the fast entry of air and water. The mucus, associated with earthworm cast being hygroscopic in nature absorbs water, prevents water logging and improves water- holding capacity too. There is abundant evidence that concentration of exchangeable calcium, sodium, magnesium, potassium, phosphorus and molybdenum are higher in earthworm casts then in surrounding soil. Hidalgo *et al.* (2002) [11] reported that application of vermicompost increased percentage pore space and water holding capacity, while decreased the bulk density and percentage of air space. Arancon *et al*. (2004) [2] conducted an experiment on vermicompost processed form food waste and paper wastes in ohio state conditions under high plastic hoop tunnel. The vermicompost was applied at the rate 5-10 t ha-1 and supplemented by inorganic fertilizer only to equalize the initial fertilizer rates of 85-155-125 kg ha-1 NPK. They reported that vermicompost significantly increased leaf area (37%), number of plant runners (36%), and shoot biomass (37%) in strawberry cv. 'Chandler' as compared to other sources. This response could have been due to production of plant growth regulators by microorganism during vermicompost. Singh *et al.* (2008) [27] recorded increased plant spread, leaf area, dry matter and total fruit yield in strawberry with the application of vermicompost @ 2.5 to 10 t ha-1 in combination with inorganic fertilizers. Baviskar *et al.,* (2011) [4] reported the maximum fruit weight, fruit length and fruit breadth in sapota with application of vermicompost @ 15 kg plant-1.

c. Effect of Forest Litter on Plant Growth, Yield and Quality of Horticultural crops

In forest with year's long life cycle, litter is a major source of nutrient systematically enriching the soil. These forest tree leaf litters can be applied as an organic amendment for the production of agricultural crops. To meet the nutrient demand of the crops especially for the resource poor farmers, the use of organic materials would be an inevitable practice for a long time to come. Depending on the agro-ecological zone, leaf litters of broadleaf-deciduous, evergreen-conifers and mixed broadleaf-conifers are used. Yavari *et al.* (2008) [33] conducted a trial to investigate the interaction of organic substrates and fertilizers on productivity and quality of strawberry with four different organic media (S1; Persian turpentine trees leaf mold (50%) + mineral soil (50%), S2; oak leaf mold (50%) + mineral soil (50%), S3; cypress leaf mold (50%) + mineral soil (50%) and S4; liquorice processing wastes (50%) + mineral soil (50%) and three levels of complete fertilizer (0, 0.5 and 1 g L-1). The results showed that plants grown in liquorice processing wastes (50%) + mineral soil (50%) had highest numbers of floral buds, fruit yield and shoot and root fresh and dry weights. While Vitamin C content was the greatest in cypress leaf mold (50%) + mineral soil (50%) substrate. The interaction of substrates with nutrient solution did not show considerable increase in productivity and quality of strawberry. Khatun *et al*. (2010) [14] reported that effect of different leaf litter on growth and yield of okra and resulted leaf litters had significant effect on the growth and yield of okra. Chhetri *et al.* (2012) [6] conducted a study which was aimed at generating information on how farmers perceive, utilize and manage leaf litter forests in West-Central Bhutan. The study found that despite having access to chemical fertilizers, soil fertility management for the farmers is mainly based on the use of leaf litters as Farymard manure. *Quercus griffithii, Q. Lanata* and *Pinus spp.* were the main leaf litter tree species in the studied areas and it was observed that *Quercus spp*. being most preferred by farmers as it is easy to decompose and gave more yield compared to other leaf litters.

B. Effect of Biofertilizers on Plant Growth, Yield and Quality of Horticultural crops

a. Effect of Azotobacter on Plant Growth, Yield and Quality of Horticultural crops

Azotobacter is a free living (non-symbiotic), aerobic, nitrogen fixing organism and this gram negative bacteria belongs to family Azotbacteriaceae. There are seven species of *Azotobacter* viz. *A. beijrinckii, A. chroococcum, A.vinelandii, and A. paspali, A. agills, A. insigins* and *A. macrolcytogenes. A. chrcoccum* appeared more in acid soils and arable soils while *A.beijarinckii* in neutral and alkali soils. Apart from nitrogen, this organism is capable of producing antibacterial and antifungal compounds, hormones and siderophore (Sharma 2002) [23]. When *Azotobacter* inoculants applied to the crops either a seed treatment or seedling root dip or soils treatment, large number of *azotobacter* cells sticks to the seed or roots and multiply rapidly in the soils along with the developing root and form a thick sheath of bacterial population around roots. *Azotobacter* prefers to thrive mainly in soil close to roots. For their multiplication the food is derived either form dead organic matter present in the soils or from root exudates excreted by the developing roots. In this routine course of activity they fix atmospheric nitrogen. Initially it fixes for their own build- up, but very soon population stabilises and fixed nitrogen is released to the close vicinity of roots. Thus released nitrogen is quickly absorbed by the plant. Subba Rao (1993) [29] reported that *Azotobacter* cells are not usually present on the rizoplane (root surface) but are in abundant in the rhizosphere (the soil immediately surrounding roots.) Ranna and chandel (2003) [21] used biofertilizer and nitrogen to strawberry cv. 'Chandler' and found that *Azotobacter* inoculated plants attained maximum plant height (24.92 cm) more number of leaves per plant (26.29 cm), more leaf area (96.12 cm2), number of runners per plant (18.70), heavier fruit (10.02gm), more fruit length (35.9mm), and more fruit breadth (22.91mm), as compared to all other treatment. Umar *et al.* (2010) [30] reported that application of 25% nitrogen through green leaf manure of subabul (*Leucaena leucocephala*) + 75% nitrogen in the form of urea augmented with biofertilizer resulted in maximum plant height (20.9cm), plant spread (27.8 cm), leaf area (70.0 cm2), fruit size (38.4 x 28.9 mm), TSS (6.83 oB), total sugers (4.85 %), fruit weight (16.9 g) and yield (358.2 q ha-1) of strawberry. Singh and Singh (2009) [29] studied the effect of biofertilizer and bioregulators on growth, yield and nutrient status of strawberry cv. Sweet Charlie and observed highest fruit set yield and optimum fruit quality when it was inoculated with *Azotobacter* and Azospirillum @ 2kg ha-1 each, along 60 kg nitrogen ha-1 and 100ppm GA3.

Pattanayak *et al.* (2001) [19] reported *Azotobacter* inculation enhanced fruit yield of okra from 3.8 to 4.2 t ha-1. But when FYM is added at the rate of 5t ha-1 along with *Azotobacter* increased yield from 4.7 (Uninoculated but supplement with FYM) to 5.3 t ha-1 Dahama (2002) reported that application of *Azotobacter* increased the yield of wheat, rice, maize, pearl millet and sorghum by 0-30% over control. Apart from nitrogen, this organism is also capable of producing antibacterial antifungal compounds and hormones, which proves to be beneficial to the health, growth and productivity of crops. Yadav and chaudhauri (1999) [31] reported that *Azotobacters*, besides fixing the atmospheric nitrogen, are also known to synthesize and secrete auxins, vitamins, growth promoting substances and antifungal antibiotics. Extensive field experiments in India on *Azotobacter* inoculation of seed or seedling of onion, brinjal, tomato and cabbage under different agro-climate condition founded that its inoculation saves 10-20% nitrogenous fertilizers. Shrama *et al.* (2010) [24] study the effect of integrated nutrient management on growth, vegetable yield and quality of tomato hybrid cv. Kuber Geeta. Combined application of seedling dip with *Azotobactor* @ 2kg ha-1 +75% nitrogen + full dose of PK+ full dose of FYM significantly increase the growth, yield and quality characters.

b. Effect of Phosphate Solubilizing Bacteria (PSB) on Plant Growth, Yield and Quality of Horticultural crops

The role of PSB as a biofertilizers is unique in making the fixed soil phosphorous available to plants. Biofertilizer produces plant growth regulating substances, which promotes root growth (Greaves and Webley, 1969) [10]. Zargar *et al.* (2008) [34] found the significant effect on number of primary flowers (8.0) per plant, number of secondary flowers per plant (10.0), total number of flowers per plant (7.0), number of primary fruit per plant (7.0), number of secondary fruit per plant (10.0) and total number of fruit per plant (17.0) by the combined application of PSB + nitrogen 225 kg ha-1 and phosphorous 150 kg ha-1 in strawberry. Gogoi *et al.* (2004) [9] found that application of PSB along with single super phosphate significantly increased the growth and yield parameters in banana due to more availability of phosphorous. Baghel *et al.* (2004) [3] conducted an experiment on response of phalsa cuttings to biofertilizers and observed that the maximum number of leaves per shoot, higher leaf area, percentage of success and survival of cutting was found under PSB in slurry form. Dar *et al.* (2010) [8] found the application of 75 per cent recommended dose of fertilizer (NPK) along with PSB as soil application @ 2 kg ha-1 proved to be most profitable and remunerative for production of okra crop under sub-tropical conditions of Jammu region (J&K). Baviskar *et al.* (2011) [4] reported that the maximum fruit weight (125.87 g) and number of fruits per plant (1569.33) was recorded when the plants treated with combined application of 250 g PSB + 250 g *Azotobacter* per plant in sapota.

C. Combined Effect of Organic Manures and Biofertilizer on Plant Growth, Yield and Quality of Horticultural crops

Iqubal *et al.* (2009) [12] reported that the strawberry plant attained the height of 21.24cm with 28.16cm plant spread, 74.95 cm2 leaf area and fruit size (37.62 × 28.01 mm) and fruit weight (15.87g) with the application of 25% nitrogen through FYM augmented with *Azotobacter* which was at par with the plant with cent percent nitrogen in the form of Urea in combination with *Azotobacter*. Kirad *et al.* (2009) [15] studied the effect of different recommended fertilizers rate considered as control (N:P:K - 100:80:60 kg.ha-1), Farmyard manure (20 t.ha-1), vermicompost (5 t.ha-1), poultry manure (5 t.ha-1), rhizosphere bacteria culture (4 kg.ha-1) alone and in combination with different reducing levels of recommended fertilizers rate. The yield of strawberry was statistically at par with 75% recommended fertilizers rate +25% vermicompost + rhizosphere bacteria culture in comparison to other treatments. Quality parameters of strawberry were increased with decreasing level of chemical fertilizers. Maximum plant spread (32.37 cm) and fruits per plant (8.77), fruit yield per hectare (8.07 t), shelf life (3.95 days) were recorded with 75% recommended fertilizers rate + 25% vermicompost + rhizosphere bacteria culture treatment, while maximum plant height (20.35 cm) and acidity (0.83%) were associated 75% recommended fertilizers rate + 25% Vermicompost**.**

Dadashpour and Jouki (2012) conducted an experiment on the influence of different organic combinations on yield and quality of strawberry cv. Kurdistan. The experiment comprised of five organic nutrient treatment combinations including the recommended dose of N, P and K through chemical fertilizer as control. Combined application of manure + *Azotobacter* +woodash + phosphorus solubilizing bacteria + oil cake improved significantly fruit diameter (3.11cm), length (3.95 cm), volume (20.397cm3), weight (11.11g), total sugars (7.95%), total soluble solids (9.01°B), acidity (0.857), TSS: acidity ratio (11.12) and yield (238.95 g/plant). While, Gupta and Tripathi (2012) studied the efficacy of *Azotobacter* and vermicompost and vermicompost alone on vegetative growth, flowering and yield of strawberry cv. Chandler. They reported that combined application of *Azotobacter* @ 7 kg ha-1 + vermicompost @30 t ha-1 significantly increased the plant height of plant, (19.45 to 17.65 cm) number of leaves, (63.60 to 59.60) number of runners per plant, (5.34 to 4.32) where as maximum number of flowers, (67.48 to 64.51) and fruit set (39.21 to 36.19). Similarly, Singh *et al.* (2012) [28] reported the higher TSS and total sugar with lower acidity (0.481 per cent) under the application of vermicompost + *Azotobacter* + *Azospirillum* +PSB in strawberry.

Lata *et al.* (2013) [17] studied that impact of integrated nutrient management practices on the vegetative growth parameters of strawberry. The maximum growth in terms of height of the plant, number of leaves per plant, length of leaves and width of leaves were recorded in the treatment of *Azotobactor* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM at 30 t ha-1. Verma and Rao (2013) studied the impact of INM on soil properties, plant growth and yield parameters of strawberry cv. Chandler. Treatment combination of *Azotobacter* + PSB + vermicompost + 50 % recommended dose of NPK recorded highest plant height, plant spread, leaf area per plant, fruit weight, number of fruits per plant, yield per plant, and yield per hectare. Singh *et al.* (2015) [26] studied that effect of vermicompost and biofertilizer on strawberry and reported that application of vermicompost + *Azotobacter* + PSB +

Arbuscular mycorrhiza produced maximum plant height, plant spread, number of leaves, leaf area and yield. Yadav *et al.* (2011) [32] reported maximum plant height, fruit length and fruit width after combined application of vermicompost and *Azotobacter* with 100 per cent recommended NPK in papaya. Anburani and Manivannan (2002) [1] reported that, FYM at 25 tonnes ha-1 along with 100 per cent NPK + biofertilizers (*Azospirillum* + Phosphate solubilizing bacteria) recorded the highest fruit set, number of fruits and estimated fruit yield in brinjal cv. Annamalai. Jayathilke *et al*. (2002) [13] reported considerable increase in onion bulb yield after the application of *Azotobacter* + vermicompost + chemical fertilizers. A significant yield was noticed when vermicompost was substituted by the farmyard manure**.** Chaudhary *et al*. (2003) [5] reported that the application of vermicompost at 200 g plant-1 + FYM manure at 250 g plant-1, enhanced sustainability and yield in cabbage and tomato. Prativa and Bhattarai (2011) studied that effect of integrated nutrient management on the growth and yield of tomato. Maximum plant height and number of leaves per plant were observed with treatment 16.66 mt ha-1 FYM + 8.33 mt ha-1 vermicompost + NPK. Highest number of fruit clusters, maximum fruit weight and fruit yield (25.74 mt ha-1) were recorded in treatment16.66 mt ha-1 FYM + 8.33 mt ha-1 vermicompost + NPK.

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