Maximizing Effect Of Mineral Fertilizers By Compost And Biofortified

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Abstract: The objectives of this study were to determine if reduced rates of inorganic fertilizer coupled with biofortified composted (incorporation some plant growth rhizobacteria plus arbuscular mycorrhizal fungi with compost) will produce plant growth, N and P concentration, grain and straw yield levels equivalent to those with full rates of the fertilizer and the minimum level to which fertilizer could be reduced when compost or biofortified compost were used. The amendment of soil with biofortified compost increased the proliferation of the total bacteria in the rhizosphere of wheat plants compared with compost. The application of compost enriched the rhizosphere with fungi more than the biofortified compost treatment. Compost enhanced both spore production and the percentage of mycorrhizal root colonization of wheat plants as compared with the NPK treatment, while biofortified compost highly increased both the mycorrhizal spore numbers and the percentage of mycorrhizal root colonization when supplementing 60% mineral fertilizer as compared with other treatments. Results showed that, 60% or 70% mineral fertilizer plus biofortified compost or compost, respectively produced plant growth, yield and nutrient concentration that were statistically equivalent to the full dose of mineral fertilizer without compost. Thus soil supplementing with mineral fertilizer raised the efficiency of mineral fertilizer and would decrease the required mineral fertilizer rate to plants about by 30 to 40%, in addition, to reduce the pollution of environment. Hence, use of bioorganic fertilizers as supplementary fertilization to chemical fertilization is necessary with the above mentioned advantages.

Key words: Inorganic fertilizer, biofortified, compost, GPRP, AM fungi, wheat plant

INTRODUCTION

One potential way to decrease negative environmental impacts resulting from continued use of chemical fertilizers is inoculation with plant growth promoting rhizobacteria (PGPR). PGPR participate in many key ecosystem processes, such as those involved in the biological control of plant pathogens, N fixation, solubilization of nutrients and phytohormone synthesis (Vessey, 2003), and therefore deserve particular attention for sustainable agriculture. PGPRs are important components in the agroecosystems because not only can they contribute to nutrient availability in the soil, but they can also bind soil particles into stable aggregates, which improve soil structure and reduce erosion potential (Kohler et al., 2008). PGPR can be used both under stress for alleviating the stress on plant growth and used singly or in combination with other forms of fertilization including chemical and organic to increase plant growth and yield production. The selection of the appropriate strains for the enhanced efficiency of PGPR under different conditions is of significance. Many PGPR systems cause stimulation of root growth (Lucy, et al., 2004), sometimes via production of phytohormones by the plant or the bacteria (Shaharooma, et al., 2008). If promotion of root growth by PGPR could be achieved with high frequency in the field, PGPR may be potential tools for increasing nutrient uptake. It indicates that PGPR must be exactly screened for their growth promoting characters, and be tested under different conditions including stress for the selection of the most efficient strains.

Organic matter is known to improve soil health and availability of plant nutrients. Although some of the organic wastes are utilized to some extent in agriculture but most of them are either burnt or remained unutilized, especially in developing countries. Organic waste materials are available in huge amounts in the form of farm waste, city waste (sewage sludge), poultry litter and industrial wastes (food, sugar, cotton and rice industry). The continuous accumulation of these wastes is becoming a potential source of land, water and air pollution. These organic wastes could be used as soil amendments; however, direct application of waste materials in raw form is usually not suitable for soil health. As per the conventional practice, organic wastes (either composted or non-composted) are being used in t ha⁻¹ for the improvement of crop productivity (Terrance et al., 2004). Thus, the availability of organic materials/wastes in bulk volumes to be applied at several t ha⁻¹ could be a limiting factor in its extensive use and may also not be cost effective. In addition, our findings support the work of other scientists who reported that application of compost (an organic material) could save ~20-35% mineral N fertilizer (Nevens and Reheul, 2003).

Incorporation of microorganisms in organic matter enables easy-handling, long-term storage and high effectiveness of biofertilizers. Application of biofortified organic matter significantly increased the growth and
yield of soybean compared to full dose of NPK fertilizer (Awad and Turky, 2007). It implies that inoculation composites with PGPR strains further improved the effectiveness of organic fertilizer.

The objectives of this study were to determine (1) if reduced rates of inorganic fertilizer coupled with biofortified (incorporation some PGPR plus AMF with compost) will produce plant growth, yield, and nutrient uptake levels equivalent to those with full rates of the fertilizer and (2) the minimum level to which fertilizer could be reduced when inoculants were used.

**MATERIAL AND METHODS**

**Biofertilizer:**

Four plant growth promoting rhizobacteria (PGPR) strains used included two strain belonged to free-nitrogen fixing (*Azotobacter chroococcum* and *Azospirillum brasilense*), one strain belonged p-solubilizing (*Bacillus megaterium*) and *Pseudomonas fluorescens* belonged to promoting of root growth that have been used in previous studies (Awad and Turky, 2007). These strains were obtained from microbial culture collection of the Agriculture Microbiology Dept. NRC, Cairo, Egypt. In addition, the arbuscular mycorrhiza fungi used was mixed strains belonged to *Glomus* spp.

Before application to composted material, the PGPR producing bacterial inoculum was prepared in flasks and each flask containing 250 mL broth was inoculated with selected strains of bacteria and incubated for 72 hours under shaking (100 rpm) conditions at 28 ± 1°C. An optical density of 0.5 measured at a wavelength of 535 nm was achieved by dilution to maintain uniform cell density (10^7–10^8 cfu mL^-1). The mycorrhizal inocula consisted of roots, hyphae, spores and growth media from a pot culture of onion plants colonization with *Glomus mosseae* NRC31 and *G. fasciculatum* NRC15 previously isolated from Egyptian soils and multiplied in a mixed medium composed of peat: vermiculite: perlite at the ratio 1:1:1 (v:v:v) (Badr El-Din et al. 2000). The inoculum material contained 273 spores g^-1 on oven dry base in addition to the infected roots pieces (the infectivity 10^7 propagules).

**Composting Procedure:**

Rice straw (Table 1) was subjected to decomposition by pure cultures of *S. aureofaciens* NRC22 and *T. viride* NRC6 under field conditions (Badr EL-Din et al., 2000). Cornstalks were used to make a 3x4m^2 frame by tying them together with lateral binding threads. Approximately 2 t chopped material was prepared for each compost heap and divided into ten parts. An activator mixture (40 kg (NH)\(_2\) SO\(_4\) plus 50 kg superphosphate and approximately 200 kg fine clay loam soil) for the 2 t of material was well mixed by hand and divided also into ten portions. A portion of the chopped material was scattered over the experimental area, then, a portion (29 kg) of the activator mixture was spread by hand over it and moistened either with water or a diluted culture of *S. aureofaciens* NRC22 and *T. viride* NRC6. The moisture was considered satisfactory when a handful of straw would wet the hand but not drip (about 70% water holding capacity). The straw was then thoroughly stamped down. The first layer of 20 cm height was then built. The other nine layers were built over the first layer in the same manner. After the heap reached 2.0 m in height, it was well stamped down, and the entire surface of the heap was covered with a thin layer of mud and left to compost for approximately 45 days. The heap was turned from the middle to the exterior after 15 and 30 days, and water was added to obtain a suitable moisture level inside the heap. The heaps were harvested and samples were taken for nutrient analysis. The chemical analyses of rice straw and composted organic wastes were determined (Table 1). About 50% recoveries were achieved. The compost materials were divided into two parts. The first part enriched with biofertilizers and the second part leave as it. The inoculated compost was incubated for 3 more days before being mixed with soil and packed in plastic pots.

**Table 1:** Chemical analysis of rice straw and compost.

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Rice straw (Before composting)</th>
<th>Compost</th>
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<tbody>
<tr>
<td>Organic matter (%)</td>
<td>94.41</td>
<td>51.90</td>
</tr>
<tr>
<td>Organic C (%)</td>
<td>54.85</td>
<td>30.1</td>
</tr>
<tr>
<td>Total N (%)</td>
<td>0.84</td>
<td>1.90</td>
</tr>
<tr>
<td>NH(_4)N (mg/kg)</td>
<td>36.96</td>
<td>1350</td>
</tr>
<tr>
<td>NO(_3) (mg/kg)</td>
<td>91.63</td>
<td>15</td>
</tr>
<tr>
<td>Total P (%)</td>
<td>0.29</td>
<td>0.90</td>
</tr>
<tr>
<td>Available P (%)</td>
<td>0.005</td>
<td>0.012</td>
</tr>
<tr>
<td>Total K (%)</td>
<td>0.13</td>
<td>0.80</td>
</tr>
<tr>
<td>pH (1:5 H(_2)O)</td>
<td>8.69</td>
<td>7.50</td>
</tr>
</tbody>
</table>
Inoculation Technique:

Microbial inoculants were prepared by mixing the four microbial strains in proportions of 1:1:1:1 (v:v) before applied to the compost. Microbial inoculants applied to the compost at the rate of 100 ml/kg compost. Mycorrhizl inoculation was done by mixing it compost at rate of 50g /kg compost.

Experimental Design:

A greenhouse experiment was conducted under natural illumination. The different rates of mineral fertilizer (F) combined with biofortified compost (BC) or compost (C) without biofertilizers was compared to the full rate of fertilizer (100%) without inoculants (positive control). Experiments were set up by planting five wheat seed (Triticum aestivum L. var Giza164) directly into each 30 cm-diameter pots containing the growth medium. A newly cultivated sandy soil (0.18%; total N, 0.014; NH$_4$-N, 14 mg kg$^{-1}$; NO$_3$-N, 8 mg kg$^{-1}$; Olsen available P, 6 mg kg$^{-1}$ and pH 7.6, from Falouga, El-Tahreer province) was air dried and sieved to 2 mm before it was mixed with the composts or biofortified. The design was a 5×3 factorial randomized complete block with was used with four replicates. The five fertilizer treatments were 100%, 80%, 70%, and 60%, and an application rate of 50% was used as the negative control. The three treatments were no inoculation, compost without biofertilizers, and biofortified compost. The 100% fertilizer rate was N 60 kg as N, P 30 kg as P$_2$O$_5$ and K 50 kg as K$_2$O. The fertilizer used was ammonium nitrate, superphosphate, and potassium sulphate. The fertilization of planted pots was carried out by mixing the appropriate amount of mineral fertilization treatment and pots were filled.

Plant Harvest And Analysis:

Rhizosphere samples were collected at 80 days after sowing (DAS) from each treatment for microbiological analysis. Plant samples were taken at the tillering and panicle stages to determine plant dry weight, N and P content (two growth-limiting nutrients). This time was chosen for nutrient analysis because in preliminary tests, it was observed that concentration of nutrients decreased with age of tissue (Awad and Fawzy, 2005). Total N and P were determined in shoot and roots of wheat plants. Dry weight was recorded after drying the samples at 70°C for 48 h in an oven until they reached a constant weight. At maturity, grain and straw yield were recorded.

Chemical Analysis:

Shoot tissues were digested in H$_2$SO$_4$ and H$_2$O$_2$ for determination of total P and N according to the methods described by Kalra and Maynard (1991). Nitrogen content of the digest was determined by Kjeldahl method and P-content was measured by the molybdate blue method. Organic matter was determined by ignition in a muffle furnace at 550±25°C for 5 h (Michiels et al, 1979).

Microbiological Analysis:

For the microbiological analysis of rhizosphere samples, the technique described by Lonw and Webley (1959) was followed. Plants were gently removed from the soil and were shaken to remove loosely adhering soil particles. A sterile razor blade way used to cut 1-cm-long root segments 1 cm below the crown. Root segments from seedling (one g fresh weight) were placed into a sterilized test tube containing 10 ml sterile water. The serial dilution plate method was used for counting total bacteria on modified soil extract yeast agar medium (Mahmoud el al., 1964) and fungi on Martin's medium (Allen 1953). The percentage of root colonization with AM fungi was evaluated using the magnified intersect method described by McGonigle et al., (1990). Roots were carefully washed free from dry soil under a stream of tap water. The roots were cleared in 2.5% KOH at 90°C and stained with trypan blue (0.05% in 1:2:1 lactic acid: glycerol: water, v: v: v).

Mycorrhizal Spore Counting:

Spores were extracted by blending 100-g subsamples of wheat rhizosphere in one liter of tap water for 20 s to release inter-radical spores. These samples were wet sieved through a 37-μm sieve (Kormanik and McGraw 1982), resuspended in dionized water and extracted at the interface of a 70% sucrose/water gradient following centrifugation at 1700 r.p.m for 3 min. Total spore numbers were counted in a nematode counting dish under the low power of a dissecting microscope.

Statistical Analysis:

Data were analysed using SPSS for Windows (Statistical Package for the Sciences System) by means of a one-way ANOVA and subsequently differences between treatments (multiple comparisons) were determined using Duncan’s multiple range tests.
RESULTS AND DISCUSSION

Mycorrhizal Root Colonization:
Results illustrated in Table 2 indicate that the percentage of root colonization of wheat plants amended with mineral fertilizers or mineral fertilizer plus compost was found to be relatively low at tillering stage. This indicates that, this soil had relatively low infectivity of indigenous mycorrhizal fungi. In addition, the limitations of root exudates during early stage of wheat plants may restrict flow of energy to the fungus and prevent extensive colonization. On the other hands, plant fertilized with mineral fertilizers plus biofortified compost, percentage of root colonization was increased (Table 2). This result is in accordance with Fares (1997) who found that mycorrhizal root colonization in wheat plants was increased at the late growth stage compared with vegetative stage. Under moderate levels of mineral fertilizers (50, 60 and 70%) plus compost significantly stimulation effect on mycorrhizal root colonization was found. But fewer than 100% of mineral fertilizer the degree of mycorrhizal colonization may be reduced. Several workers have shown that at either very high or very low mineral fertilizers can certainly alter characteristics of root colonization (particularly reducing arbuscule development) and markedly decrease AM fungal biomass per plant, including both biomass in roots and in soil (Smith and Read, 2008). The latter observation has been significantly extended by Balzergue et al. (2011), who showed marked reductions in appressorium formation on pea (Pisum sativum) roots at high P (750 μm; i.e. about 2 orders of magnitude higher than soil solution), which, importantly, was mediated by internal plant-derived signals.

Table 2: Percentage of mycorrhizal root colonization and spore numbers in the rhizosphere of wheat plants response to different fertilizer treatments at 80 days after sowing.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Compost</th>
<th>Biofortified</th>
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<tbody>
<tr>
<td></td>
<td>Colonization (%)</td>
<td>Spore numbers (no./100 g dry soil)</td>
</tr>
<tr>
<td>100%</td>
<td>19</td>
<td>351d</td>
</tr>
<tr>
<td>80%</td>
<td>20</td>
<td>502c</td>
</tr>
<tr>
<td>70%</td>
<td>27</td>
<td>531b</td>
</tr>
<tr>
<td>60%</td>
<td>31</td>
<td>566a</td>
</tr>
<tr>
<td>50%</td>
<td>20</td>
<td>583a</td>
</tr>
</tbody>
</table>

Values in each column with different letter(s) are significantly different at $P<0.05$.

Results presented in Fig 1 illustrate the population intensities of bacteria and fungi in the rhizosphere of wheat plants. The population densities of studied microorganisms were increased significantly at $P<0.05$ in case of enriching the rhizosphere with compost or biofortified compost. Total bacteria occurred in higher densities in the rhizosphere of wheat plants growing in soil treated with biofortified compost or compost with all level of mineral fertilizers as compared with the 100% mineral fertilizer without compost (Fig. 1). These fast increases in the microbial intensities indicates a high nutritive value of compost present particularly nitrogen and phosphorus (Table 1). Compost application to the sandy soil generally raised the activity of soil microorganisms through
enriching soil organic matter (Dick, 1992 and Dick & Tabatabai 1992). The increase of microbial density associated with biofortified compost or compost application might be ascribe to both new microbial biomass incorporated in the organic residues as well as the simulative effect of added nutrients (Diaz et al 2002). On the other hands, biofortified compost decreased the bacterial intensities in the rhizosphere of wheat plants. The presence of mycorrhizal fungi may cause these effects. Most reports have indicated depressive effects on bacterial numbers by mycorrhizal roots compared with non-mycorrhizal roots (Attia 1994; Olsson et al 1996).

All organic soil treatments increased the total fungal count in the rhizosphere of wheat plants as compared with soil treated with 100% mineral fertilizer (Fig 1). Sivapalan et al. (1993) found greater fungal species diversity under organic cultivation than under conventional cultivation with inorganic fertilizer. Soil amendment with biofortified compost led to a significant decrease \( (P < 0.05) \) in the proliferation of total fungi in the rhizosphere of wheat plants compared with compost. Greater microbial populations in FYM treated plots as compared to chemically amended plots were reported by Venkateswarlu and Srinivasarao (2000).

![Fig. 1: Microbial densities in the rhizosphere soil of wheat in accordance to different fertilizer treatments Growth, Yield, and Nutrient Content.](image)

Results indicated that plant heights resulting from treatment with compost plus 70% mineral fertilizer or biofortified compost plus 60% of mineral fertilizer were statistically equivalent to the heights with 100% fertilizer (Table 4). Plants that receive 60% of mineral fertilizer plus biofortified compost grew significantly taller than those with 60% mineral fertilizer plus compost.

<table>
<thead>
<tr>
<th>Percent fertilizer</th>
<th>Compost</th>
<th>Biofortified compost</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>21.2 a</td>
<td>22.95 a</td>
</tr>
<tr>
<td>70</td>
<td>19.4 b</td>
<td>19.12 a</td>
</tr>
<tr>
<td>60</td>
<td>17.8 c</td>
<td>18.9 b</td>
</tr>
<tr>
<td>50</td>
<td>15.8 d</td>
<td>19.0 b</td>
</tr>
</tbody>
</table>

Values in each column with different letter(s) are significantly different at \( P<0.05 \).

With organic matter treatments, it was possible to track changes that occurred in growth, N and P uptake. The growth of plants that received 60% to 80% of mineral fertilizer plus biofortified compost or compost was comparable to the full mineral fertilizer rate without amended (Fig. 2). The application of biofortified compost plus mineral fertilizers significantly increased shoot and root dry weight of wheat plants compared to compost plus mineral fertilizers. Generally, mineral fertilizers at rate 80% plus biofortified compost or compost had greater shoot and root dry weight compared to 100% mineral fertilizer. There were no differences among the shoot and root dry weight of wheat plants that received 70% mineral fertilizer plus compost, 60% mineral fertilizer plus biofortified compost, or 100% fertilizer at both tillering and panicle initiation stages (Fig 2 ). The positive effects of the PGPR on the yield and growth of crops such as chickpea, apricot, sweet cherry, spinach, tomatoes, sugar beet, barley and wheat were explained by N2-fixation ability, phosphate solubilizing capacity, indole acetic acid (IAA) and antimicrobial substance production (Turan et al., 2005). In the present study, organic composts fortified with high effective growth promoting rhizobacteria was also found positive effects on the growth of wheat plants amendment with biofortified compost compared with compost.
Fig. 2: Dry biomass of wheat plants with mineral fertilizer (F), mineral fertilizer plus compost (F+C) or biofortified compost (F+BC).

The amount of N per gram of wheat shoot and root tissues were statistically the same for 100% mineral fertilizer without amended and 60% mineral fertilizer supplemented with biofortified compost (Fig. 3A (shoot) and B (root)). Also, plants that received 70% fertilizer with compost produced comparable amount of N in shoot as those with 100% mineral fertilizer without amended.

Fig. 3: Nitrogen concentrations shoot of wheat (A) and root (B) with mineral fertilizer (F), mineral fertilizer plus compost (F+C) or biofortified compost (F+BC).

On a whole-tissue basis, 60%, 70%, or 80% mineral fertilizer plus biofortified gave results that were significantly equivalent to 100% fertilizer (Fig. 4). The fluctuation that occurred in 60, 70, 80% fertilizer plus compost for results on 60% fertilizer plus biofortified was also seen for N content. Results for 70% treatment were not consistent. This is different from the observations of Canbolat et al. (2006) and Elkoca et al. (2008), who reported no significant difference in root and shoot biomass of barley or seed yield and biomass of roots and shoots of chickpea, respectively, when inoculant alone or fertilizer alone was used. Based on those results, it was suggested that inoculants could be an alternative to fertilizer for chickpea (Elkoca et al., 2008). In contrast, these current results demonstrate that, for wheat, inoculants may allow reduced rates of fertilizer but that they will not replace fertilizer.

Therefore, the stimulation of N content in biofortified compost must be due to alternative bacterial effects. A combination of the activities of the plant and the inoculants (Kloepper et al., 2007; Vassey and Buss 2002) is being proposed as a model for PGPR-enhanced N uptake in plants, according to the following scenario. The PGPR promote the growth of the plant and increase the root surface area or the general root architecture (Vassey and Buss 2002; Lucy et al., 2004). Plants growing better in turn release higher amounts of C in root exudates. The
release of more C concentration increase in microbial activity, and this process continues in a cycle. The whole process makes more N available from the soil pool, influencing N flux into plant roots, and the plant is able to take up more available N. Overall, the results suggest that soil amendment with biofortified compost could be used to allow reductions in the current high rates of fertilizer and the resulting environmental problems (Shaharooma et al., 2008) without comparing plant productivity. However, it should be noted that no all amendment compost can be universal for all systems as the effectiveness may be affected by plant type, soil type, and some other factors.

![Fig. 4: Nitrogen concentration on dry whole-plant basis at 50 day after planting with mineral fertilizer plus biofortified compost (F+BC).](image)

For P, where biofortified compost contained AM fungi, P concentration was significantly the same on total plant basis but not on a per gram of tissue basis (Fig. 5). 60% fertilizer with biofortified compost gave the best result, resulting in P uptake equivalent to that with 100% fertility without amended. Compared to the positive control, significantly more P was taken up by plants treated with 60% mineral fertilizer plus biofortified compost (Fig. 5). Greatest increase in P-content occurred in plants amended with 80% mineral fertilizer plus biofortified compost or compost. Theses increase was due to an increase in the number of uptake sites per unit area of roots and greater ability of theses roots to exploited the soil for nutrient.

![Fig. 5: Phosphorus concentration on dry whole-plant basis with mineral fertilizer (F), mineral fertilizer plus compost (F+C) or biofortified compost (F+BC) plus mineral fertilizer. F fertilizer.](image)

Comparison of the grain and straw yield of wheat showed that 60% or 70% mineral fertilizer plus biofortified compost or compost were comparable to 100% mineral fertilizer without amended compost (Fig. 6). For the treatment of mineral fertilizer plus compost or biofortified compost, only biofortified-supplemented 60% fertilizer produced the same yield as 100%. The compost-supplemented 70% fertilizer treatment produced significantly lower yield compared to 100% mineral fertilizer. The results indicated that 60% of fertilizer plus biofortified compost produced comparable results with 100%, but similar treatment with 70% fertilizer was not consistent. The maximum grain and straw yield was observed in the treatment amended with 80% mineral fertilizer plus biofortified compost. These results are in agreement with those obtained by Badr El-Din et al., (2000).

Although there are several works on the role of specific strains of PGPR and rhizobia in plant-growth promotion, N₂ fixation, biofertilizer activities, and biological control, there is a need for more attention with regard to the negative effects of environmental stresses, diseases on rhizobacteria–plant interactions (Vessey 2003; Bashan et al. 2004; Morrissey et al. 2004).

Research activities aimed at achieving a better use efficiency of fertilizers, including the use of PGPR and/or arbuscular mycorrhizal fungi as supplements to fertilizers, have steadily increased in the last two decades. However, it is important to emphasize those agro-environmental problems which are not limited to the use of chemical fertilizers but also occur with manures and compost (Mitchell and Tu 2006). Both animal waste and chemical fertilizers have the potential of environmental pollution (Jarecki et al. 2008). Release of greenhouse gases (Flessa et al. 2002; Jarecki et al. 2008), ozone layer depletion (Ma et al. 2007), global warming, and acid rain are reported as negative impacts of fertilizers (Vitousek et al. 1997; Frink et al. 1999).

Microbial inoculants, such as PGPR fortified with organic compost, are promising components for integrated solutions to agro-environmental problems because inoculants possess the capacity to promote plant growth, enhance nutrient availability and uptake, and support the health of plants (Han and Lee 2005; Weller 2007; Adesemoye et al. 2008).

Different types of compost induced significant increases in dry matter: N and P concentration as compared with 100% fertilizer. These results may be due to the higher levels of organic matter and nutrients in composts (Table 1). In addition, the study by Adesemoye et al. (2008) confirmed that fortified mixed strains with organic manure were more efficient than single-strain inoculations. A proposal made by Adesemoye et al. (2009) toward solving the agro-environmental problems mentioned is integrated nutrient management (INM), which does not aim to remove fertilizer totally in the short run but to reduce the negative impacts of the overuse of fertilizers containing N, P, and other elements. The INM system promotes low chemical input but improved nutrient-use efficiency by combining natural and manmade sources of plant nutrients in an efficient and environmentally prudent manner. This will not sacrifice high crop productivity in the short term nor endanger sustainability in the long term (Adesemoye et al. 2008).

Recuena et al. (1996) reported that inoculation with selected microorganisms and furthest incubation of lignocellulosic wastes can be a useful tool for the improvement of the agricultural value of the resultant product, probably as these methods make nutrients more available to plants. The highest increase in plant dry weight, N and P concentration, grain and straw yield were obtained by the soil application of biofortified compost, Burkert and Robson (1994) showed that inoculation with AM fungi and compost increased the absorption of nutrients with low mobility in soil, such as P, Zn, N and Ca, drastically reduced damping-off caused by Pythium and Rhizoctonia solani in the first stage of plant growth, and led to an increase in plant growth (Newsham et al. 1995).

The results presented here support the hypothesis that compost or biofortified compost can improve the nutrient use efficiency of fertilizers. When the percentage of recommended fertilizer was reduced and were used, plant height, shoot dry weight, root dry weight, yield, and nutrient uptake were comparable to those with the full rate of fertilizer without inoculants. After testing different reduced fertilizer rates, under these experimental conditions, 60% or 70% fertilizer was the stable minimum to which fertilizer could be reduced if amended with biofortified compost or compost to achieve growth equivalent to 100% fertilizer without amended. This agrees with Biswas et al. (2000) who suggested an interdependence of fertilizer N inputs and inoculants for optimal gain in rice productivity.

Hence, use of bio-organic fertilizers as supplementary fertilization to chemical fertilization is necessary with the above mentioned advantages. Accordingly, the right and proper application of chemical and bio-organic fertilization is much dependent on realizing the interactions between soil, plant and microorganisms. Soil microbes...
are a big help to plant and the environment as they own some abilities that collectively enhance plant growth. Among such abilities enhanced nutrient uptake by plant is also of importance; in the presence of soil microbes, plant absorb higher amounts of nutrients and less risk of environmental pollution is likely.

REFERENCES


