POTENTIAL OF NITROGEN AND L-TRYPTOPHAN ENRICHED COMPOST FOR IMPROVING GROWTH AND YIELD OF HYBRID MAIZE

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Effectiveness of recycled organic wastes/compost enriched with nitrogen and/or L-tryptophan (L-TRP) was tested for improving the growth and yield of maize by conducting pot and field experiments. Fruit and vegetable wastes were collected from different locations and subjected to composting in a locally-fabricated unit. Composted product was enriched with 25% recommended rate of nitrogen and L-TRP @ 5 mg kg^{-1} compost. Recommended doses of chemical fertilizers (NPK) were kept for comparison. Results revealed that the application of compost enriched with N and L-TRP in combination with 50% additional dose of N fertilizer significantly increased the plant height (up to 39%), fresh biomass (up to 53%), cob weight (up to 72%) and grain yield (up to 72%) of hybrid maize in both pot and field experiments compared to control (PK fertilizer only). Comparison of enriched compost and chemical fertilizers indicated that enriched compost supplemented with 50% N fertilizer was equally effective in improving the growth and yield of maize compared with chemical fertilizers (NPK), resulting in saving of ~ 25% of recommended N fertilizer. These findings may imply that organic wastes could be recycled into value added soil amendments for sustainable agriculture to reduce the pollution threat to environments.
Key words: organic wastes, compost, soil amendments, crop production

INTRODUCTION

These days sustainability of environments is a big challenge to the scientists due to continuous release and accumulation of various kinds of waste material including organic wastes (farm, city and industrial wastes). Various options (e.g., landfill, incineration etc.) are utilized for the management of waste but composting offers the most sensible and economic way to utilize organic waste in environment-friendly manners, and at the same time it provides a high quality and inexpensive soil amendment. Through composting, organic materials are biochemically converted into humus like substances (under the condition of optimum temperature, moisture and aeration) that can be handled, stored and applied to a land without environmental impacts (Gallardo Larva and Nogales, 1987; Lasaridi and Stetiford, 1999).
Compared to organic materials, chemical fertilizers are a ready source of nutrients. However, suboptimal doses of fertilizers are applied due to high cost and poor economic conditions of the farmers. This results in lower crop yields than the actual yield potential. Composted organic material is considered a rich source of nutrients and can also play important role to conserve the soil fertility to enhance crop production on sustainable basis (Togun et al., 2003; Walkowski, 2003). The integrated use of compost and chemical fertilizers can enhance the efficiency of each other and save the farmers from economic burden. However, the basic concept underlying is to sustain soil fertility for enhanced crop production by optimizing all possible sources.

L-Tryptophan (L-TRP), a known physiological precursor of auxin (indole-3-acetic acid), is involved in a variety of plant growth and development responses (Davies, 1995; Frankenberger and Arshad, 1995). Exogenous application of L-TRP could have positive effect on the growth and yield of crop plants (Arshad and Frankenberger, 1998; Zahir et al., 2000).
Although composting is an old technique, efforts have been made to improve it with respect to quality of compost and rate of composting. Enrichment of the composted material with a ready source of nutrient and/or biologically active substances is a new approach to improve the effectiveness of compost, and could convert it into value added organic fertilizer.
Keeping the above discussion in view, organic waste material of fruits and vegetables was recycled and enriched with nitrogen and L-TRP. The enriched compost was used for enhancing the growth and yield of maize on sustainable basis.

MATERIALS AND METHODS

Pot and field experiments were conducted for evaluating the potential of enriched compost for improving the growth and yield of hybrid maize.
Organic wastes, mainly fruit and vegetable waste, were collected from various fruit and vegetable markets, restaurants and juice shops of Faisalabad city. This material was processed for composting in a locally-fabricated unit by optimizing the incubation conditions (temperature, moisture, aeration). The waste material was air-dried for 24 h to remove the excessive moisture and then placed in an oven for drying at 60°C

for 24 hr. The oven-dried material was ground into fine particles with the help of an electric grinder. The ground material was analyzed for C: N: P: K ratios (100: 2.70: 0.30: 1.96). The ground material was transferred to a composter and water was added @ 25 liter 100 kg^{-1} compost. To enhance the value of compost, nitrogen and L-TRP were added at the rate of 25% of recommended dose (175 kg N ha^{-1}) of N for maize crop and 5 mg kg^{-1} compost, respectively, and incubated at suitable temperature and aeration for 7 days under constant stirring (100 rpm). After incubation, the composted product was packed in a gunny bag prior to use. The enriched compost was also analyzed for C: N: P: K ratios (100: 25: 0.50: 3.55).

Two pot and field trials were conducted at the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad to test the response of hybrid maize (hybrid corn 786) to nitrogen and L-TRP enriched compost. A typic haplocambid sandy clay loam soil was collected, air dried, sieved and analyzed for physico-chemical characteristics. The analysis of a composite soil sample revealed a pH, 7.9; ECe, 1.6 dS m^{-1}; CEC, 6.8 cmol(+) kg^{-1} and organic matter, 0.72%.

Four seeds of hybrid maize were sown in each pot containing 14 kg soil. Recommended dose of P and K fertilizers (100 and 50 kg ha^{-1} as single super phosphate and sulphate of potash, respectively) was applied in all the treatments including control as a basal dose by mixing them in soil before pot filling. Similarly, enriched compost at the rate of 250 kg ha^{-1} was applied by mixing it in soil while filling the pots. After germination, thinning was done to maintain one maize seedling in each pot. Required amount of nitrogen fertilizer (as urea) was applied in the pots in the form of solution in two split doses after thinning and at tasseling stage according to the following treatment plan:

T_1 = Control
T_2 = Recommended N fertilizer
T_3 = Nitrogen enriched compost
T_4 = Nitrogen enriched compost + 25% N
T_5 = Nitrogen and L-TRP enriched compost + 25% N
T_6 = Nitrogen enriched compost + 50% N
T_7 = Nitrogen and L-TRP enriched compost + 50% N

The pots were arranged randomly with four replications at ambient light and temperature. Canal water was used for irrigation according to the requirements. The data regarding plant height, fresh biomass, cob weight and grain yield were recorded at maturity.

Like the pot trials, two field experiments were conducted in the research area of Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad. Hybrid maize (hybrid corn-786) was sown in a sandy clay loam soil in the month of August in a wheat-maize-wheat crop rotation system. The seeds were sown in the field with the help of a dibbler on ridges keeping row to row distance of 60 cm and plant to plant distance of 25 cm with a plot size of 10 m^2. One seed was sown per hole. Experiments were conducted according to the treatments described in pot experiments. The experiment was laid out in randomized complete block design with four replications. The whole dose of PK was applied at the time of seed bed preparation as a basal dose in all blocks, while N was applied according to the treatments in two split doses (except control) i.e. after germination and before tasseling. The enriched compost was applied as a band placement along the seed with hand drill @ 250 kg ha^{-1} according to treatment plan. Canal water was used for irrigation.

The data regarding plant height, fresh biomass, cob weight and grain yield were recorded at maturity and subjected to analysis of variance (Steel and Torrie, 1980). Means were compared by Duncan's Multiple Range test (Duncan, 1955).

RESULTS

Results of plot trials revealed that enriched compost (EC) in combination with N fertilizer significantly promoted the plant height (up to ~23%) compared with control (PK fertilizers only) (Fig. 1). Maximum plant height (26.2% greater than control) was recorded in recommended chemical fertilizers (NPK), followed by N and L-TRP EC with 50% N (22.9% higher than control), and differed significantly from control but non-significantly from chemical fertilizers. Similarly, plant height recorded in case of EC (without L-TRP) plus 50% N was statistically similar to that recorded with chemical fertilizers. However, it was significantly higher (18%) than control.

Results of field trials indicated that EC in combination with 50% N fertilizer also significantly increased the plant height (37%), however addition of L-TRP in the EC compost further increased the plant height which was 39% more than control (Fig. 1). Maximum plant height was observed where recommended dose of chemical fertilizers was applied. Rest of the treatments increased plant height which ranged from 14 to 31% compared with control. Overall, both EC with 50% N and chemical fertilizers (NPK) were equally effective treatments in improving the plant height of maize plants.

Data regarding the fresh biomass (Fig. 2) showed that EC (with or without L-TRP) and N fertilizer significantly increased the fresh biomass of maize which ranged from 25 to 53% over control in pot trials. However,

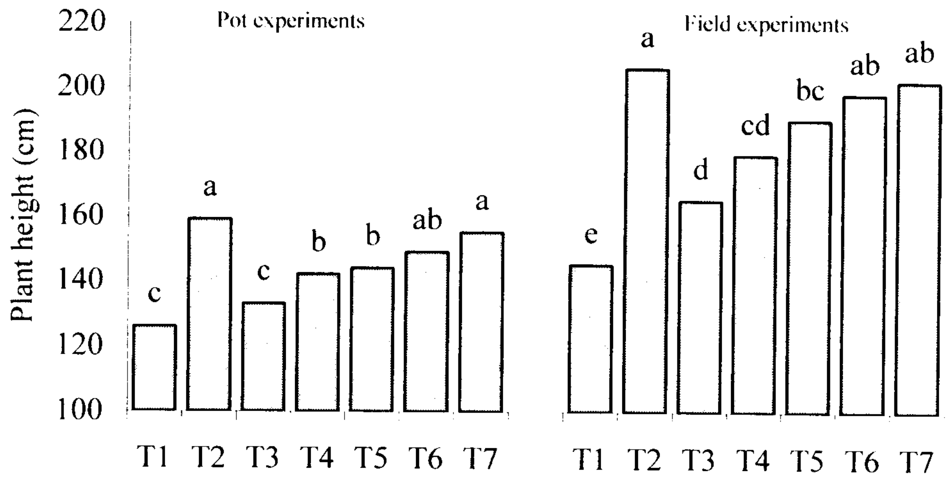

Fig. 1. Effect of enriched compost and chemical fertilizers on plant height of maize (average of 2 trials x 4 repeats).

T1: Control
T2: Recommended chemical fertilizers
T3: N enriched compost
T4: N enriched compost + 25% N
T5: N & L-TRP enriched compost + 25% N
T6: N enriched compost + 50% N
T7: N & L-TRP enriched compost + 50% N

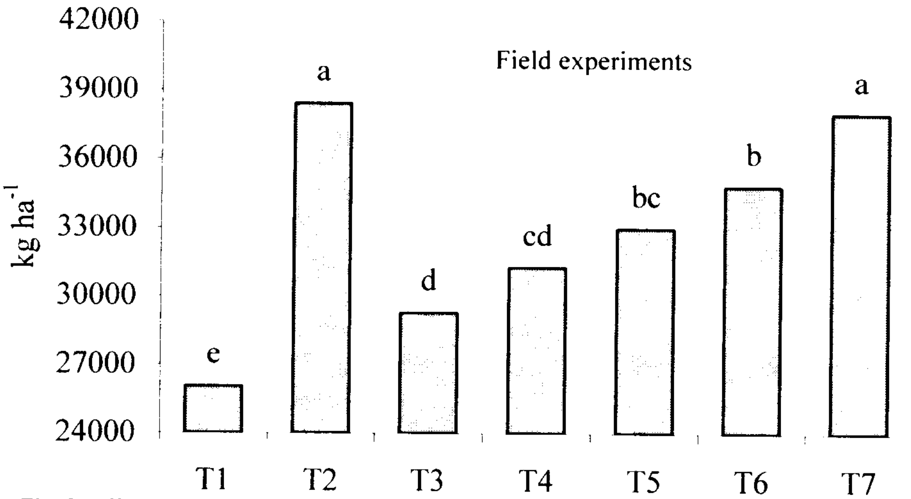

Fig. 2. Effect of enriched compost and chemical fertilizers on fresh biomass of maize (average of 2 trials x 4 repeats).

T1: Control
T2: Recommended chemical fertilizers
T3: N enriched compost
T4: N enriched compost + 25% N
T5: N & L-TRP enriched compost + 25% N
T6: N enriched compost + 50% N
T7: N & L-TRP enriched compost + 50% N

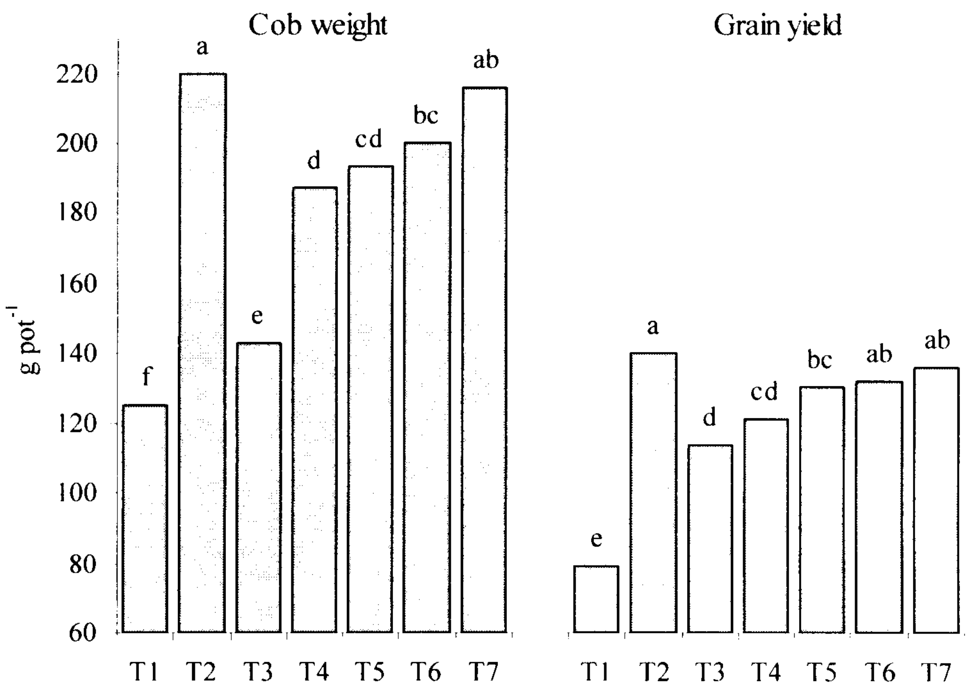

Fig. 3. Effect of enriched compost and chemical fertilizers on cob weight and grain yield of maize (pot experiments; average of 2 trials x 4 repeats).

T1: Control

T2: Recommended chemical fertilizers

T3: N enriched compost

T4: N enriched compost + 25% N

T5: N & L-TRP enriched compost + 25% N

T6: N enriched compost + 50% N

T7: N & L-TRP enriched compost + 50% N

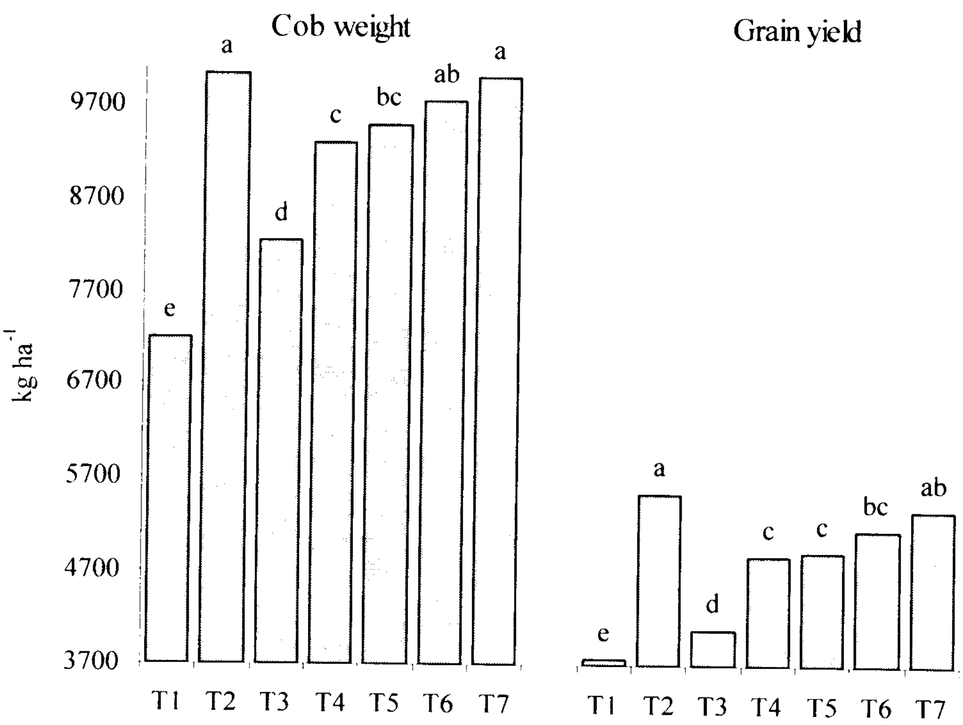

Fig. 4. Effect of enriched compost and chemical fertilizers on cob weight and grain yield of maize (field experiments; average of 2 trials x 4 repeats).

T1: Control
T2: Recommended chemical fertilizers
T3: N enriched compost
T4: N enriched compost + 25% N
T5: N & L-TRP enriched compost + 25% N
T6: N enriched compost + 50% N
T7: N & L-TRP enriched compost + 50% N

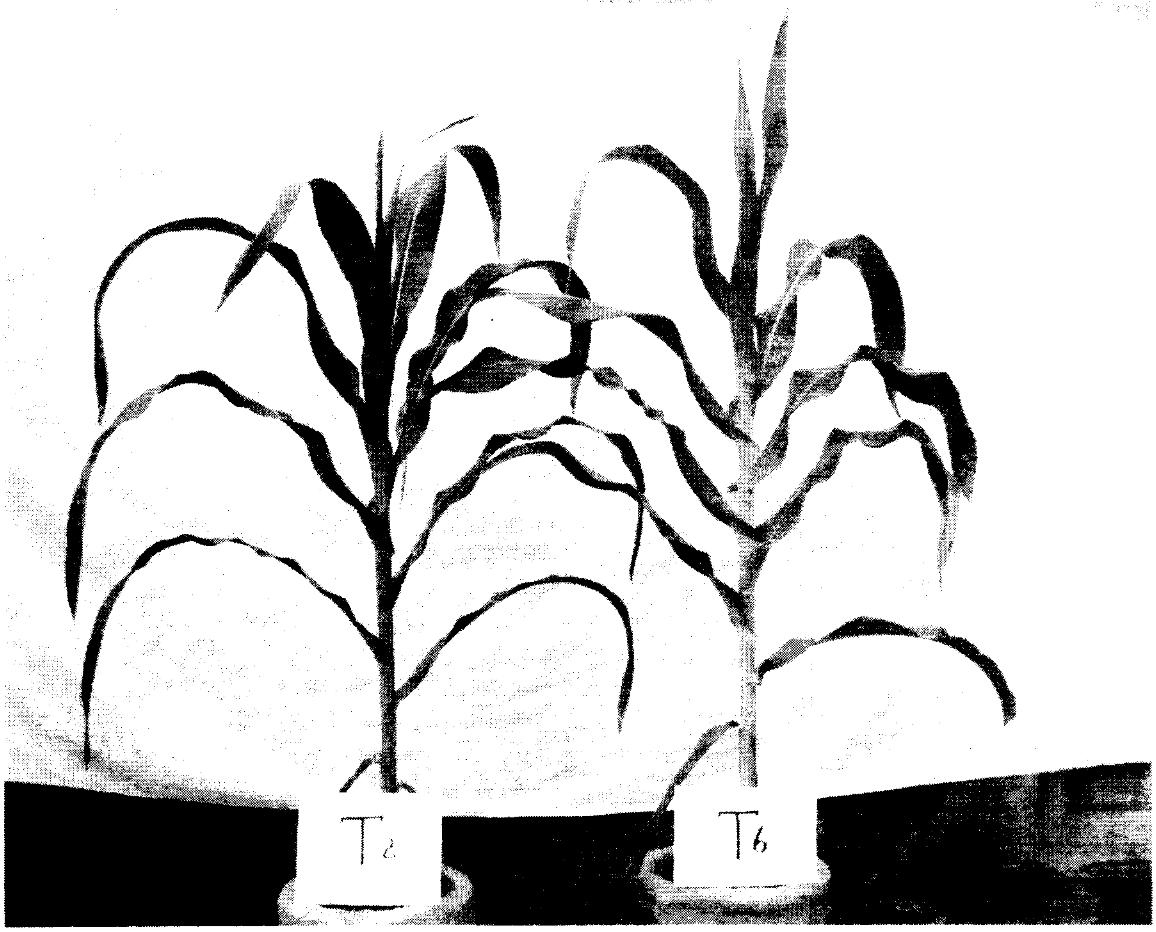

Fig. 5. Comparison of chemical fertilizers and enriched compost for improving growth of hybrid maize (T_2: NPK fertilizers, T_6: Enriched compost + 50% N)

maximum fresh biomass was observed in the case of chemical fertilizers (58.3% more than control). Next to it, L-TRP EC applied in combination with 50% N was the most effective treatment and statistically at par with chemical fertilizers. Similarly, effects of all the treatments where EC was applied in different combinations under field conditions were significant (Fig. 2). Maximum fresh biomass was observed with NPK fertilizers, resulting in a 47.4% increase over control. Next to chemical fertilizers, the most effective treatment was EC plus 50% N which gave significantly higher fresh biomass (46%) compared to control. Enriched compost (without L-TRP) plus 50% N also produced significantly higher fresh biomass (~34%) as compared to control. Overall, EC along with 50% N was the most effective treatment in both pot and field trials and significantly increased fresh biomass of maize over control but it differed non-significantly from chemical fertilizers.

Compost application also significantly promoted the cob weight. In pot trial, EC plus 50% N had significant increasing effect on cob weight (72%) compared to control, however, statistically it produced same cob weight as obtained in case of NPK (75.4% more than control) (Fig. 3). Application of EC along with 25% N also had significant effect on cob weight and caused an increase of 53.5% over control. The EC without an additional dose of N did not affect the cob weight significantly. Grain yield of maize was also enhanced significantly by the application of EC (Fig. 3). Application of EC along with 50% N caused maximum increase of 72% in grain yield. Rest of the EC treatments either alone or in combination with N fertilizer also significantly promoted grain yield (ranging from 44 to 67%). Comparison of chemical fertilizers vs. EC indicated that the application of NPK fertilizers was relatively more effective than the combined application of EC and N; however, statistically both were similar.

In the field trials, EC also gave promising results and significantly increased cob weight when it was used with N fertilizer (Fig. 4). Maximum cob weight was observed where EC plus 50% N was applied and caused an increase of 39% over control. The EC (without L-TRP) plus 50% N also produced significantly more cob weight (35.3%) than the control, followed by treatments where EC with or without L-TRP plus 25% N was applied which increased the cob weight by 31.6 and 29% compared to control, respectively. Once again, EC along with 50% N fertilizer produced almost the same cob weight as it resulted from NPK fertilizers' application and differed non-significantly from each other. Similarly, maximum grain yield (47% more than control) was recorded where NPK were applied, followed by EC plus 50% N (42.3% greater than control). The EC plus 50% N also showed better results than untreated control. EC in combination with 25% N fertilizer also significantly increased grain yield which was up to 37%.

Comparison of EC vs. chemical fertilizers (NPK) is shown in Fig. 5, which revealed that the EC along with 50% N was equally effective in improving the growth of maize compared to NPK, implying that the supplementation of chemical fertilizers with composted organic material may enhance the nutrient utilization efficiency and can save about 25% N fertilizer.

DISCUSSION

Results of both pot and field trials demonstrated the effectiveness of EC (with or without L-TRP, an auxin precursor) for improving the growth and yield of maize crop. Application of EC significantly increased the growth and yield of maize compared with control. However, combined application of EC and N fertilizer was more effective in improving the growth and yield of maize than their sole applications. The EC with 50% N fertilizer showed more promising results under both pot and field conditions causing significant improvements in plant height, fresh biomass, fresh cob weight and grain yield compared to control. In general, application of EC was found economical and saved about 25% of N fertilizer without compromising on yield. The novelty of this approach is that the EC was applied just @ 250 kg ha^{-1} as a soil amendment rather applied in tonnes as a source of organic matter as it is common among farmers since many decades. Up to 10% increases in yields of tomato and pepper have been reported in response to compost application (Cheuk et al., 2003). Our findings are supported by the work of scientists who reported that the application of compost can save ~20% N fertilizer and yield increases were up to 10% when organic wastes were applied in combination with chemical fertilizer (Pooran et al., 2002). It is very likely that N-losses due to leaching or denitrification might be reduced due to mixing of N-fertilizer with organic compost resulting in a better utilization of N by plants.

Results also revealed that the enrichment of compost with L-TRP further improved the growth and yield of maize in both pot and field experiments. As L-TRP is considered an efficient physiological precursor of auxins (IAA) in higher plants and in microbes, and could affect physiological responses of plants after uptake directly by the roots or indirectly after converting into IAA in the soil (Frankenberger and Arshad, 1995). It is now well established that the effect of L-TRP on plant growth is most likely through its conversion into IAA as evidenced by radiolabelled studies (Martens and Frankenberger, 1993). Many scientists have reported that the application of IAA increased the plant growth (Ebata et al., 1988; Awan and Alizai, 1989). This implies that the enrichment of compost with suitable concentration of plant growth regulators could further enhance the effectiveness of product for improving growth and yield of crops.

The economic analysis of enriched compost indicated that this technology is cost effective if the organic material is collected and transported by government.

In conclusion, the integrated nutrient supply and management through judicious use of organic, mineral and biofertilizer will lead to sustainable and high crop production. The complementary use of various sources of nutrients is advantageous as it helps in improving fertilizer use efficiency and may help in maintaining soil health and crop productivity. It is therefore possible to shift the yield plateau to a higher level with complimentary use of organic biofertilizer along with chemical fertilizers than chemical/mineral fertilizer alone. The recycling of organic waste for the development of useful soil amendment through blending/enriching with nutrients or plant growth regulators could help in getting sustainability in agriculture as well as in environments.

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