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RESPONSE OF RADISH TO INTEGRATED USE OF NITROGEN FERTILIZER AND RECYCLED ORGANIC WASTE

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Abstract

Recycling of organic wastes could convert them into a value-added product that may be effective even when applied in small quantity compared with the traditional use of their huge quantities. Two field trials were conducted to evaluate the integrated use of recycled organic waste and chemical fertilizers for improving growth and yield of radish. Recycled organic waste (compost) was enriched with an auxin precursor L-tryptohan (@ 6 mg kg^{-1} compost) and this enriched compost was tested alone and in combination with recommended nitrogen fertilizer @ 50 and 75%. Enriched compost + 50% recommended nitrogen fertilizer produced significantly better results in almost all the parameters except number of leaves $plant^{-1}$ and root length. Other parameters like leaf area, root girth, total biomass $plant^{-1}$, and yield ha^{-1} were increased by 82, 68, 132.9 and 167.6%, respectively compared to control. Results revealed that enriched compost with 50% recommended nitrogen fertilizer gave almost same results as the 100% N fertilizer alone, thus saving half of the Nitrogen.

Introduction

Before the advent of chemical fertilizers, farmers mostly relied on organic materials as the sole source to promote health and productivity of the soil. Then the era of chemical fertilizers started and farmers neglected the use of organic matter because chemical fertilizers were an effective substitute as a ready source of nutrients. This has resulted in the abundance of waste material in the system and people try different options to get rid of this. When the waste material is disposed into rivers, streams and water channels, it creates water pollution and when this material is burnt, it causes air pollution and loss of nutrients. Where the sewage sludge is directly used as manure without any treatment, the heavy metals and other toxic substances in it may get entry into the food chain. For the reuse of organic waste material many approaches are being used in which composting is one of them. Other approaches are combustion/incineration and landfills. Composting, a process of controlled biological decomposition of organic residues into partially humified material is used to convert organic waste into suitable forms for land application (Shaharoona & Arshad, 2003). Hogland *et al.,* (2003) described the aerobic processes in a small-scale composting reactor and evaluated how these processes could be optimized. The optimized composting process had a relatively short turn over time for organic matter at the same time the temperature of about 60ºC decreased the problems with pathogens and weeds in the mature compost. The compost had a high nutritional value, with high concentrations of especially nitrogen, potassium and phosphorus, while the contaminations by heavy metals and other toxic substances were very low. Cheuk *et al.*, (2003) investigated the composts made from greenhouse wastes and found to have high nutrient values and good physical properties, and could be used as high quality growing media. The finished composts were tested in a greenhouse against the conventional growth media (sawdust) and resulted in a 10% yield increase by using the compost.

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L-tryptophan (L-TRP) is a physiological precursor of auxin biosynthesis both in microbes and higher plants. Among the plant growth hormones, auxin is well known for growth and development of plants. Exogenous application of L-TRP has been reported to improve the growth and yield of various crops (Frankenberger & Arshad, 1995; Zahir *et al*., 2004, 2005). Similarly, Zahir *et al*., (2000) reported that addition of L- TRP as an auxin precursor substantially increased auxin production by microbes present in soil. The amount of auxins released from the precursor, required for better growth, varies with the crop and also with variety. Enrichment of recycled organic waste with biologically active substances such as L-TRP could convert the composted organic waste into a value-added product for improving crop yields.

Integrated use of chemical fertilizers and recycled organic waste may be an approach for sustainable production of crops. This may improve the efficiency of chemical fertilizers and thus reduce their use. Integrated use of organic and inorganic fertilizers can improve crop productivity and sustain soil health and fertility (Satyanarayana *et al*., 2002). Integrated use of organic wastes and chemical fertilizers is beneficial in improving crop yield, soil pH, organic carbon and available N, P and K in sandy loam soil (Rautaray *et al*., 2003). Application of compost along with chemical fertilizers has been reported to give highest yield and maximum return. This treatment may also help to alleviate certain nutritional problems that result in poor health and individual productivity (Aminuddin, 1995).

Keeping this in view, the present study was conducted to evaluate the potential of integrated use of recycled organic waste and chemical fertilizers for improving growth and yield of radish. However, the novelty of this approach is that the recycled organic waste was enriched with an auxin precursor L-TRP and was applied as side dressing just @ 300 kg ha^{-1}compared to the previous use of tons ha^{-1}.

Materials and Methods

Two field trials were conducted on sandy clay loam soils having pH 7.6 and 7.8, ECe 3 and 2.81 dS m^{-1}, organic matter 0.63 and 0.65%, available phosphorus 17.2 and 16.5 mg kg^{-1} and extractable potassium 213 and 195 mg kg^{-1}, respectively, to evaluate integrated use of recycled organic waste and chemical fertilizers for improving growth and yield of radish.

Recycling of organic waste: Fruit and vegetable waste material was collected from different local fruit markets. Un-decomposable pieces of stones and polythene bags were removed and material was crushed to extract moisture. After extraction, the material was oven dried at 55 ± 5 ºC for 24 hours. The dried material was ground to finer particles with the help of mechanical grinder to increase the surface area. The oven dried ground material was transferred into specially prepared 'composter' and water was added @ 30 liters per 100 kg of waste material. In composter, oxygen inlet was available to aerate the process of decomposition. The material was incubated for six days with constant shaking (50 RPM). The finished product was analyzed to have C, 23.15%; N, 2.27%; P, 0.31%; K, 1.59%; Fe, 597 mg Kg^{-1}; Cu, 1.31 mg Kg^{-1}; Zn, 46.11 mg Kg^{-1} and Mn, 45.27 mg Kg^{-1}. The resulting compost was enriched with L-TRP in solution form @ 6 mg kg^{-1} compost before testing in integration with chemical fertilizers for improving the growth and yield of radish in two field trials.

Field trials: Two field trials were conducted during 2004-05. Recommended doses of NPK @60-50-60 kg ha^{-1} (Urea, SSP and SOP, respectively) were applied. The whole dose of PK was applied at the time of sowing as a basal dose while N was applied according to the treatments after germination. A local radish variety "Lal Pari" was sown on ridges. The enriched composted material was applied @ 300 kg ha^{-1} after thinning in the form of side dressing along the seedlings. Canal water was used for irrigation. Following treatments were replicated four times in randomized complete block design in both the trials:

- Untreated Control
- Nitrogen fertilizer @ 60 kg ha^{-1} (recommended N fertilizer)
- Enriched compost alone
- Enriched compost + 30 kg ha^{-1} N fertilizer (50% of the recommended N fertilizer)
- Enriched compost + 45 kg ha^{-1} N fertilizer (75% of the recommended N fertilizer)
- Enriched compost + 60 kg ha^{-1} N fertilizer (recommended N fertilizer)

PK was applied as basal dose to all treatments.

Number of leaves and leaf area was recorded at maturity. After harvesting, data regarding the plant biomass, length and girth of the roots, root weight and yield was recorded. Root and leaf samples were collected for analysis of NPK contents. The data were subjected to statistical analyses as described by Steel & Torrie (1984) using the randomized complete block design.

Results

The present study consisted of two field trials where integrated use of recycled organic waste and chemical fertilizers was evaluated for improving the growth and yield of radish. Data regarding different parameters is presented here.

Number of leaves was observed statistically same in recommended nitrogen fertilizer and in the treatments where enriched compost was applied in integration with different levels of chemical fertilizer (Table 1). The maximum numbers of leaves (13.33) were observed where enriched compost was applied with 100% recommended nitrogen fertilizer and number of leaves were 19% more compared to control. Statistically, there was no significant difference among all the treatments.

Regarding leaf area it is revealed from Table 1 that all the treatments differed significantly from control. Maximum leaf area (254.73 m^2) was observed where 100% recommended nitrogen fertilizer was applied with enriched compost followed by the combination of compost with 75 and 50% of recommended nitrogen fertilizer. Compost with N fertilizer (even 50% of the recommended) showed statistically significant improvement in the leaf area as compared to all other treatment.

Highest root length 12.41 and 11.65 cm was observed where 100 and 75% of recommended nitrogen fertilizer was applied in integration with enriched compost (Table 1). Both of these treatments were statistically significant compared to control. Integration of 50% of N with enriched compost increased the root length significantly (14.6%) compared to control but it was statistically similar where only chemical fertilizer was applied and with all other treatments as well.

Table 1. Effect of integrated use of recycled organic waste and chemical fertilizers on different yield and yield contributing parameter of radish

Treatments	Average of data from 2 field trials, each with four replications					
	Number of leaves	Leaf area (cm^2)	Root length (cm)	Root diameter (cm)	Total biomass $plant^{-1}$ (g)	Yield ($t\ ha^{-1}$)
Control	11.20B	115.68E	9.51B	5.58D	255.81E	24.74D
Recommended N fertilize (60 kg ha^{-1})	11.7AB	171.01C	11.23AB	8.60B	442.36D	59.10C
Compost	10.81B	144.00D	10.04AB	6.15C	286.60E	33.90D
Compost + 50% recommend N (30 kg ha^{-1})	11.60AB	210.66B	10.90AB	9.42A	595.76C	66.20B
Compost + 75% recommended N (45 kg ha^{-1})	11.79AB	235.82A	11.65A	9.47A	649.89B	72.22B
Compost + 100% recommended N (60 kg ha^{-1})	13.33AB	254.73A	12.41A	9.58A	701.42A	82.90A

Data sharing same letter(s) in a column don not differ significantly at $p= 0.05$

Results regarding root girth showed significantly higher root girth in all the treatments over control (Table 1). Minimum root girth (5.58 cm) was observed in control where as maximum root girth (9.58 cm) was recorded where 100% of recommended nitrogen fertilizer with enriched compost was applied. Where enriched compost was used in combination with chemical nitrogen (50, 75 and 100% of recommended dose) were statistically same but produced significantly higher root girth compared with chemical N and enriched compost alone as well as untreated control. Combination of enriched compost with 50% recommended fertilizer increased root girth by 9.5% compared to the treatment where only chemical fertilizer was applied, thus also saving 50% of chemical nitrogen.

In case of total biomass, all the treatments showed highly significant results compared to control, except treatment where only compost was applied (Table 1). Enriched compost along with 100% N produced maximum biomass (701.4 g) followed by combination of compost with 75 and 50% N. In all combinations of chemical fertilizer with enriched compost, total biomass of plant became double compared to control. Integration of compost with 50% of N produced 34.7% more biomass compared to N fertilizer alone.

Data (Table 1) regarding yield indicates that maximum yield (82.9 t ha^{-1}) was obtained where enriched compost was used with 100% recommended nitrogen. Integration of enriched compost with chemical fertilizer in all combinations increased yield significantly compared to control. Data revealed that combination of chemical fertilizer with enriched compost increased yield by 167.6, 191.9 and 235.1% when compost was integrated with 25, 50 and 100% chemical N fertilizer, respectively. Comparison of chemical fertilizer alone and enriched compost with 50% of the recommended N fertilizer showed 12% higher yield in case of enriched compost with half of the recommend nitrogen fertilizer thus saving 50% N.

Data revealed that N concentration of roots was significantly increased in all treatments (Fig. 1). Where enriched compost was integrated with 50%N, the N concentration was 52% higher compared to control, but compared with chemical fertilizer alone, the difference was non significant. In case of phosphorus, significant increase in concentration was observed where 75 and 100% nitrogen was integrated with enriched compost. Whereas for potassium no significant change was observed either with recommended nitrogen applied alone or in combination with compost.

Maximum nitrogen concentration (2.1 and 2.35%) in leaves was observed where 75 and 100% nitrogen was integrated with enriched compost (Fig. 2). Nitrogen concentrations in leaves were statistically same where recommended nitrogen and compost were applied alone or combination of 50% nitrogen with enriched compost. Statistically significant increase in phosphorus concentration was observed where recommended nitrogen fertilizer alone or in combination with enriched compost (100% N) was applied. All other treatments were statistically non significant compared with control and with each other. Maximum potassium concentration (1.87) in leaves were found where only recommended nitrogen fertilizer was applied and this treatment was statistically significant compared to all other treatments except compost with 100% recommended nitrogen fertilizer.

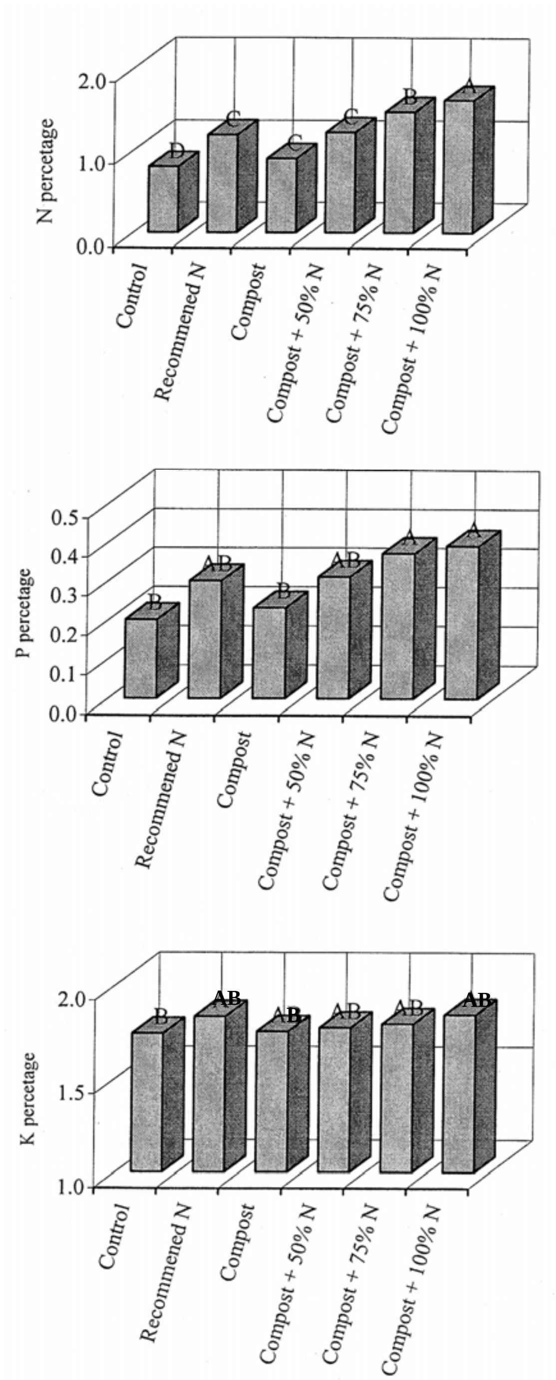

Fig. 1. Effect of integrated use of recycled organic waste and chemical fertilizer on NP and K concentration of root. Bars sharing same letter(s) do not different significantly from each other at $p \leq 0.05$.

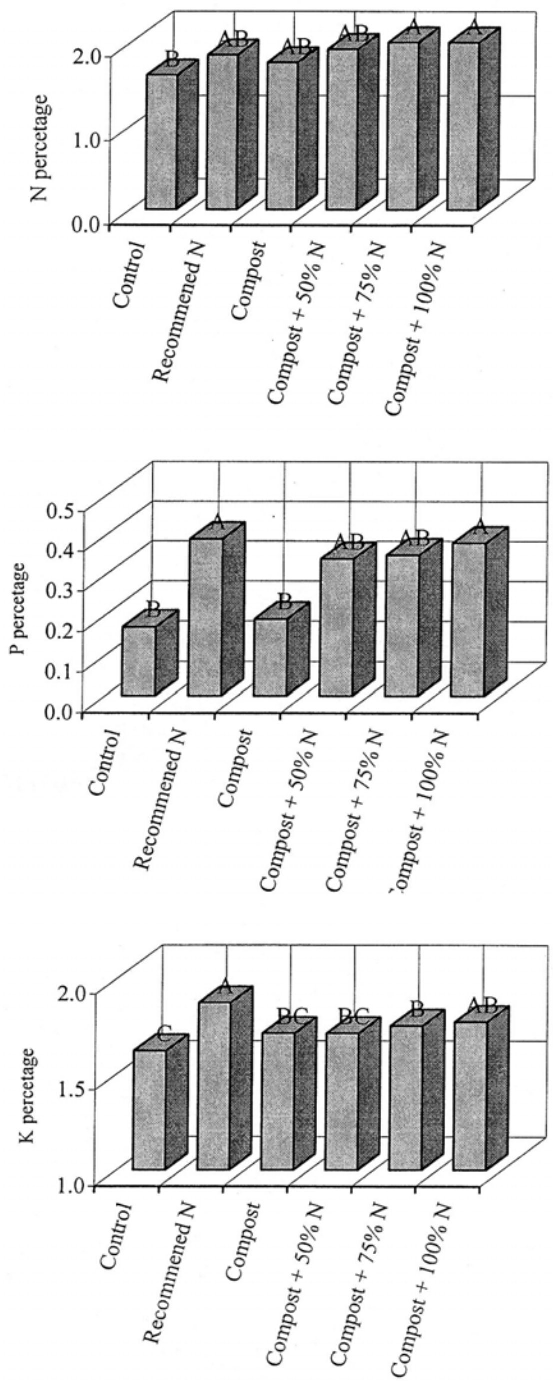

Fig. 2. Effect of integrated use of recycled organic waste and chemical fertilizer on NP and K concentration of leaf. Bars sharing same letter(s) do not different significantly from each other at $p \leq 0.05$.

Discussion

In this study, integrated use of recycled organic waste and chemical fertilizers for improving growth and yield of radish was investigated. Results showed a significant increase in the growth parameters in response to the application of recycled organic waste along with different levels of recommended nitrogen fertilizer. Integrated use of recycled organic wastes and chemical fertilizers was beneficial in improving the growth and yield of radish.

In the present study, recommended nitrogen fertilizer was found more effective to increase the growth and yield parameters like number of leaves (4.5%), leaf area (47.8%), root length (18.2%) root girth (54.2%), fresh biomass (72.9%), and yield (13.9%) compared with untreated control. It also significantly increased nitrogen concentration in roots (48.8%) and in leaves (14.9%) as compared with untreated control.

Integrated use of chemical fertilizers and recycled organic waste (enriched compost) + 50% recommended nitrogen fertilizer in our study showed more promising results and increased almost all the growth parameters like leaf area, root length, root girth, fresh biomass, and yield plot^{-1}. Enriched compost + 50% recommended nitrogen fertilizer in radish crop also significantly increased the nitrogen concentrations as compared with untreated control. It is very likely that when we apply enriched compost along with chemical fertilizers, compost not only slowly releases nutrients from itself but also prevents the losses of chemical fertilizers through denitrification, volatilization and leaching by binding the nutrients and releasing with the passage of time. Thus compost prevents nutrients losses (Arshad *et al*., 2003). Hence, the increase in the growth and yield of radish could be attributed to enhanced nutrient use efficiency in the presence of organic fertilizer being an excellent source of macro- and micro-nutrients (analysis given in materials and methods). This premise is supported by the fact that the total N, P and K uptakes in radish (Figs. 1, 2) were increased manifold in response to combined application of recycled organic waste and chemical fertilizers. Other researchers have reported similar kind of findings that the use of organic material enhanced the fertilizer use efficiency (Muneshwar *et al*., 2001; Nevens & Reheul, 2003). Moreover, addition of L-TRP to composted organic material might have increased the concentration of plant hormone auxin in the organic fertilizer which might also have affected root growth and subsequently shoot growth. Many scientists have reported that the application of L-TRP to the rooting medium improved the plant growth (Arshad *et al*., 1994, 1995; Arshad & Frankenberger, 1998; Zahir *et al*., 1997, 2000, 2005). Application of recycled organic waste + 50% recommended nitrogen fertilizer showed similar results as with recommended nitrogen fertilizer and saved about 50% of the recommended nitrogen fertilizer with out compromising on yield. These results go parallel to those of Aminuddin (1995) that application of compost along with chemical fertilizers has been found to give highest yield and maximum return in many vegetables including radish. These results are also in agreement with the findings of several researchers like Jayathilake *et al*., (2002) who found that onion plant height and number of leaves per plant were highest upon treatment with biofertilizers + 50% recommended N through organic manures + 50% N and 100% PK through chemical fertilizers. An additional increase of 14.25% in plant height and 30.72% in leaf number was observed in plants treated with vermicompost + chemical fertilizers compared to the control. An increase in leaf area with integrated use of organic manures, biofertilizers and chemical fertilizers over the control was observed. Similarly, Prabu *et al*., (2003) while investigating the effect of integrated use of organic fertilizers with reduced levels of inorganic fertilizers concluded that number of leaves and fresh and dry weight of the okra plant increased significantly with increase in fertilizer, FYM and biofertilizer application. Leaf area per plant also increased with an increase in fertilizer, FYM and biofertilizer application. Our findings are also supported by the work of many scientists who reported that the application of compost can save ~ 20% N fertilizer (Pooran *et al*., 2002). Up to 10% increase in yield of tomato and pepper have been reported in response to compost application (Cheuke *et al*., 2003).

It is concluded from this study that compost + 50% recommended nitrogen fertilizer showed statistically similar results with recommended nitrogen fertilizer alone in most of the parameters. It also indicated that use of compost + 50% recommended nitrogen fertilizer was as effective as recommended nitrogen fertilizer alone because it improved the use efficiency of recommended nitrogen fertilizer and reduced their cost. By using recycled organic waste (compost) + 50% recommended nitrogen fertilizer we can save 50% nitrogen fertilizer as compared to recommended nitrogen fertilizer alone. However, in our study, compost was not applied as a source of organic matter because for this purpose it is applied in tons where as we applied only@ 300kg ha^{-1}. As this recycled material was applied with N fertilizer it was effective even when applied in lower amount. Further work is needed to standardize the method and rate of application for this compost. Future work should also focus on the development of crop specific compost enriched with chemical fertilizer and options of enrichment with some other biologically active substances or beneficial microorganisms may also be explored.

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