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Optimizing crop residue-based composts for enhancing soil fertility and crop yield of rice*

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Effective waste management, especially of crop-based residues has become an issue of immense significance in agriculture since the harmful effects of chemical inputs in agriculture are looming large over the environment. In this context, recycling of crop residues and organic wastes through composting represents the key technology for the production of organic manures and their use as nutrient supplements in soil to replace the chemical fertilizers.

As per FAO "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil microbial activity and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs". The utilization of crop residues to prepare composts and their application in nutrient management of crops is one such option. Compost provides a stable organic product that improves the physical, chemical and biological properties of soils, thereby enhancing soil quality and crop production (Gaind and Nain 2010). When compost is applied correctly, several beneficial effects on soil properties are recorded, including creation of suitable conditions for root development leading to higher yields and improved quality of crops (Lata *et al.* 2005, Gaind *et al.* 2006, Pandey *et al.* 2009). The role of organic matter or carbon in agriculture is well known and composts are known to improve soil structure and humus content as well as supply macro and micronutrients (Vasanthi and Kumaraswamy 2000).Most of the earlier work has been focused on cereal residue-based compost prepared by natural method of composting. The present investigation was undertaken with composts prepared by the improved method of composting using inoculum of efficient microorganisms (Lata *et al.* 2005) using legume crops (chickpea, pigeonpea stover) and mustard stover, on which very scanty information is available. The effect of these bioaugmented composts was compared with recommended chemical fertilizers on productivity of rice and selected soil microbiological parameters in a field experiment.

A field experiment was carried out at the experimental farm of Indian Agricultural Research Institute; New Delhi during rainy (*kharif*) season of 2007 to evaluate the effect of three composts prepared using pigeonpea stover, chickpea stover and mustard stover. These crop wastes were composted in the pits for 60 days using inoculation of selected bacteria, fungus and actinomycetes (Lata *et al.* 2005) with mustard cake amendment to lower the C:N ratio to 50:1. These composts were analyzed for total carbon; N and humus content (Hesse 1971) as given in Table 1. The experiment was laid out in randomized block design with four replications and treatments including: T_1-$N_{120}P_{60}$; T_2-$N_{60}P_{30}$; T_3-pigeonpea stover compost @5tonnes/ha; T_4-chick pea stover compost @ 5tonnes/ha; T_5 - mustard stover compost) @ 5tonnes/ha.Nitrogen was applied through urea and P (P_2O_5) through single super phosphate at the time of transplanting rice (var. Pusa Basmati1) as per treatments. Composts were applied before 20 d of transplanting rice in field. The row-to-row and

Table 1 Characteristics of the composts

Compost	C (%)	N (%)	C/N	Humus (%)
Pigeonpea stover compost	23.78	1.28	18.57	11.36
Chickpea stover compost	27.26	1.25	21.80	11.14
Mustard stover compost	24.26	1.22	19.80	10.82

* Short note

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plant-to-plant distance of 20 × 20 cm was maintained during transplanting of crop which was done on 27 July 2007.

Before sowing, a composite soil sample and after harvesting of the rice, soil samples (0–15cm depth) from each plot were taken and analyzed for electrical conductivity and *p*H ,organic carbon content ,soil available N ,P and K as per standard protocols.The soil of experimental site was loamy in texture with *p*H of 8.2 (1:2.5, soil: water), EC of 1.13 (dS/m), organic carbon content of 0.59%, available N of 276.2 kg/ha, available P of 19.3 kg/ha and available K of 207.4 kg/ha. Grain and straw yields of rice were recorded at harvest and contents of N, P and K were analyzed separately.

Dehydrogenase activity was assayed in soil as per method by Casida *et al.* (1964). The values were expressed as µg of triphenyl formazon (TPF)/g/day. Alkaline phosphatase activity was expressed as µg p-nitro phenol released/g soil/h. (Tabatbai and Bremner 1969). The triplicate sets of data for the various parameters evaluated were subjected to ANOVA (Analysis of Variance) in accordance with the experimental design (using MSTAT-C statistical package to quantify and evaluate the source of variation, and CD values were calculated at P level of 0.05. SD values are depicted in the graphs as bars.

Proper soil management ensuring continued maintenance and build up of soil fertility is indispensable for greater productivity from the available agricultural land. Organic manures and composts represent important inputs in this context for maintaining soil and microbial health and continuous nutrient supply to the crop. In this investigation, the influence of three types of composts generated using pigeonpea, mustard and chickpea stover (Table 1) wer evaluated individually in rice crop. The field experiment was undertaken with recommended and 50% dose of fertilizers and application of the three composts. The grain and straw yields of rice was statistically at par (Table 2) with the application of composts in comparison to application of 50% recommended dose of N and P (T_2). This can be attributed to the slow release of organically bound forms, known to be associated with the release of macro and micro nutrients during the course of microbial decomposition of the applied organic matter. The contents of N, P and K in both grain and straw were found to be at par in the treatments with application of composts and $N_{60}P_{30}$ treatment (Table 3). Chickpea compost enhanced the N content in grains of rice over $T_{1.}$ However, there were no significant differences among the three composts and the values of N and P were statistically at par. The K content recorded in both grain and straw was significantly higher with the application of composts over T_1/T_2 (Table 3). The uptake of nutrients usually follows the yield pattern, however in our investigation, this increase may be attributed to higher availability of K in compost and increased utilization of native P due to organic acids produced during decomposition of organic matter (Jacobsen 1995) .

Soil available P and K increased with the application composts over T_1 and T_2 respectively (Table 4). This can be attributed to both the higher K content of composts as well as the conversion of soil non exchangeable K into exchangeable K^+. The beneficial effect of organic manuring on K availability includes minimizing the losses due to fixation as well as solubilization of K-through the action of organic acids released during decomposition (Das *et al.* 2010). A significant improvement in soil available P was recorded with composts in comparison to T_1, which may be due to endogenous soil P solubilization through biochemical process Overall, it can be concluded from our investigation that these composts @ 5tonnes/ha provide half of the recommended dose of chemical fertilizers N and P, even in the case of a

Table 2 Effect of compost and fertilizers on grain and straw yields of rice

Treatment	Grain yield (tonnes/ha)	Straw yield (tonnes/ha)	Thousand grain weight (g)
T_1 $N_{60}P_{30}$	3.35	5.73	52.61
T_2 $N_{120}P_{60}$	4.38	7.58	53.16
T_3 pigeonpea stover compost	3.45	6.18	52.74
T_4 chickpea stover compost	3.42	6.09	52.25
T_5 mustard stover compost	3.39	6.08	51.77
CD (*P*=0.05)	0.41	0.63	1.94

Table 3 Effect of compost and fertilizers on N P and K content in rice grain and straw

Treatment	Nutrient content (%)					
	N		P		K	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1 $N_{60}P_{30}$	0.83	0.32	0.32	0.12	0.43	1.09
T_2 $N_{120}P_{60}$	1.07	0.39	0.39	0.18	0.49	1.19
T_3 pigeonpea stover compost	0.82	0.35	0.32	0.16	0.58	1.43
T_4 chickpea stover compost	0.87	0.31	0.33	0.16	0.59	1.38
T_5 mustard stover compost	0.82	0.30	0.30	0.17	0.60	1.47
CD (*P*=0.05)	0.11	0.06	0.03	0.03	0.04	0.11

nutrient intensive crop such as rice. Supplementing compost with half of the recommended dose of chemical fertilizer may therefore improve not only the crop yield but enhance soil fertility in a better manner. Long-term evaluation of these composts with rice and other cereal crops may provide a more realistic and reliable estimate of their superiority over cereal crop-based composts.

Organic matter is known to function as a source of energy for soil micro-flora which in turn brings about transformation of inorganic nutrients in a form that can readily be utilized by growing plants. Organic farming practices such as application of compost improves biological health of soil which can be assessed by a number of microbial activity parameters in terms of dehydrogenase and alkaline phosphatase. In our study, microbial activity of soil samples showed a positive trend in the treatments in which composts were applied. The top three ranked treatments, in terms of Dehydrogenase activity were T_3, T_4 and T_5 (Fig 1). Highest alkaline phosphatase activity was recorded in T_3, followed by T_5 and T_4 (Fig 2, 3). Similar observations have been recorded by researchers in rice and wheat fields in which composts were applied (Gaind *et al.* 2006, Gaind and Nain 2010).

Table 4 Effect of compost and fertilizers on available N P and K in soil after the harvest of rice

Treatment	Available nutrient		
	N	P	K
	(kg/ha)	(kg/ha)	(kg/ha)
$N_{60}P_{30}$	220.1	17.15	173.80
$N_{120}P_{60}$	250.9	21.28	180.90
Compost 1	229.2	20.50	195.60
Compost 2	222.2	19.83	190.30
Compost 3	220.7	19.95	191.40
CD (P=0.05)	18.23	1.97	6.75

On the basis of the present investigation, it can be concluded that composts prepared by different crop wastes including legumes can supply nutrients which were found to be at par with $N_{60}P_{30}$ treatment. The application of composts @5tonnes/ha an help to save at least 60 kg N and 30 kg P, thereby saving up to 50% on expenditure related to chemical fertilizers and can meet all the K requirements of rice crop. Moreover, microbial activity was also stimulated by compost application. Therefore, the bioconversion technology for crop waste recycling through microbes provides an eco-friendly option for for sustainable agriculture. These composts may be used for integrated nutrient management of crop by supplementing half of the recommended dose of chemical fertilizers to maximize the benefit to crop yield and soil fertility.

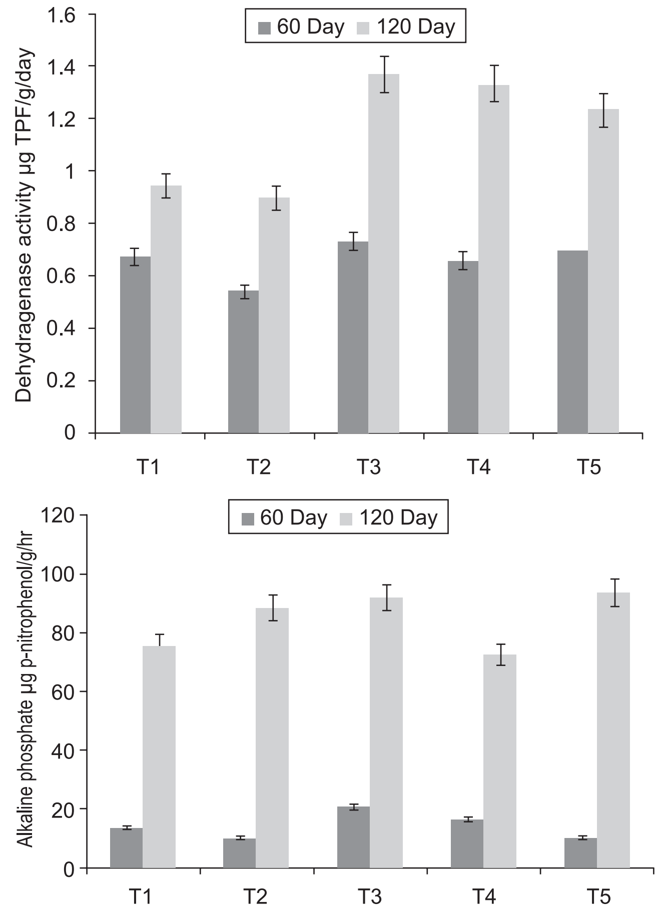

Fig.1 Effect of different treatments on dehydrogenase(TPF µg/g/day) and alkaline phosphatase (µg p-nitro phenol released/g soil/hra)activity of soil . Treatments include T_1-$N_{120}P_{60;}$ T_2 -$N_{60}P_{30}$; T_3-Pigeonpea stover compost @5tonnes/ ha; T_4 Chickpea stover compost @ 5tonnes/ ha; T_5- Mustard stover compost @5tonnes /ha

SUMMARY

A field experiment was conducted using rice crop (var. Pusa Basmati1) to evaluate the effect of different crop residue based composts (prepared using pigeon pea stover, chickpea stover and mustard stover) on the post-harvest availability of macronutrients, crop growth and yields along with soil microbiological parameters. Significant enhancement in the soil microbial activity in terms of dehydrogenase and alkaline phosphatase was recorded in the pigeonpea composts amended treatments (T_3) vis a vis 100% recommended dose of N and P ($N_{120}P_{60;}$ T_2). Grain and straw yields of rice were significantly higher in this treatment, as compared to 50% recommended dose of N and P fertilizer ($N_{60}P_{30}$). Compost application also increased the soil available P and K as compared to $N_{60}P_{30}$ indicating that compost@ 5tonnes/ha fulfils the requirement of P and K in rice crop. The observations emphasized the utility of using on-farm residues as composts as supplements with chemical fertilizers for

improving soil health and plant productivity of rice crop.

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