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Effect of compost enriched with NPK fertilizers and neem oil coated urea on productivity and nutrient use efficiency in maize

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Abstract: A field experiment was conducted in Zonal Agricultural Research Station, Navile, Shivamogga to know the impact of different compost enrichment methods on productivity and NPK use efficiency and their uptake by maize. The different compost enrichment methods adopted were: compost alone, recommended package of practice (RPP), compost enriched with NPK fertilizers, compost enriched with neem oil coated urea (NOCU) + PK fertilizers and compost enriched with neem cake + PK fertilizers. Compost + NOCU + PK fertilizers recorded significantly higher grain yield (8626 kg ha^{-1}) and also higher N (210.8 kg ha^{-1}), P (65.4 kg ha^{-1}) and K (205.8 kg ha^{-1}) uptake by maize. The highest N, P and K use efficiency of 34.5, 59.9 and 118.1 kg grain per kg N, P and K applied respectively, was recorded in the compost + NOCU + PK fertilizers treatment. Compost + neem cake + PK fertilizers enrichment method recorded significantly higher available N (192.5 kg ha^{-1}), available P (37.6 kg ha^{-1}) and available K (182.2 kg ha^{-1}) in soil over RPP (154.8 kg ha^{-1}, 33.7 kg ha^{-1} and 161.4 kg ha^{-1} available N, P and K, respectively).

Key words: Enriched compost, Neem oil coated urea, Nutrient uptake, Nutrient use efficiency

Introduction

Rising costs of commercial fertilizer and increasing demand to produce more food will continue to increase the value of manure and waste organic material as a nutrient source for crops and to regenerate degraded soils. Use of compost prepared through enrichment is the best remedy for maintaining soil quality as well as productivity and partial replacement of mineral fertilizer. The integrated use of organic nutrient sources and chemical fertilizers increases the potential of organic fertilizers and improve the efficiency of inorganic fertilizers. So their use could be reduced up to certain level. Incorporation of chemical fertilizers in composted materials improves its efficiency and reduces losses (Ahmad *et al.,* 2008). Enriched organic manures, besides supplying chemical fertilizer to the current crop, often leaves important part as residual effect on the succeeding crops in the system. Apart from the nutritional value, these organic materials help to improve physico-chemical and biological properties of soils and thereby help to increase fertility and productivity. The direct application of fertilizers is subjected to losses. In case of N fertilizers leaching and volatilization losses are more, only 30 to 40 per cent of the added N fertilizers used by the crops (Rizwan Ahmad *et al.,* 2008). The overall P use efficiency of applied phosphatic fertilizers is lower than optimal, only 15 to 20 per cent of applied phosphorus is recovered by the first crop, because of the formation of insoluble P compounds in soil (Biswas, 2011). Soil K deficiency is mostly associated with the slow release of exchangeable K as compared to plant K acquisition. This necessitates the enrichment of compost with fertilizers to improve the nutritional status of the compost.

Material and methods

A field experiment was carried out at the Zonal Agricultural Research Station, Navile, Shivamogga during *kharif* 2011. The experiment was tried in a factorial RBD design with factor A at two levels (with red earth and without red earth enrichment) and factor B at five levels (different compost enrichment methods) replicated three times. The compost was enriched with fertilizers, neem cake, red earth and consortium of agriculturally beneficial microorganisms as per the treatment requirements and kept for incubation. The initial soil sample from the experimental plot was collected and analyzed for chemical and physical properties. The properties of the experimental soil are presented in Table 1. After the harvest of the crop, soil sample and plant samples were collected separately from each plot and analyzed the nutrient content by using standard methods.

Table 1. Initial properties of soil at the experimental site

Parameters	Values
pH (1:2.5)	5.39
Electrical conductivity (dSm^{-1} at 25°C)	0.06
Organic carbon (g kg^{-1})	3.4
Cation exchange capacity [cmol (p^+) kg^{-1}]	8.8
Available N (kg ha^{-1})	156
Available P (kg ha^{-1})	30
Available K (kg ha^{-1})	165
Exchangeable calcium [cmol (p^+) kg^{-1}]	3.5
Exchangeable magnesium [cmol (p^+) kg^{-1}]	1.8
Available sulphur (mg kg^{-1})	11
Texture	Sandy loam

The nutrient use efficiency was calculated by using the following formula

$$NUE = (GY_F - GY_C) / AF_N$$

Where GY_F = Grain Yield in the nutrient added plot (kg ha^{-1})

GYc = Grain yield in the control plot (kg ha^{-1})

AF_N = Amount of nutrient applied (kg ha^{-1})

NUE was calculated separately for N, P and K using their respective AF_N values

Results and discussion

All the compost enrichment methods significantly increased the grain yield over only compost application (Table 2). The highest grain yield was observed in compost enriched with NOCU+ PK fertilizers (8626 kg ha^{-1}). As nitrogen is one of the essential nutrient for crop growth and development, steady increase in the supply of nitrogen by NOCU by reducing the leaching and volatilization losses might have accelerated the activities of enzymes, protein synthesis, synthesis of growth promoting substances, cell division and cell elongation. Being the constitute of chlorophyll, nitrogen increases the photosynthetic efficiency of crop which might have resulted in higher yield. The increase in this treatment was 108.5 per cent over control (compost only). Use of NOCU also saved 20 kg N ha^{-1}. The findings are in accordance with the findings by Sharma and Prasad (1996). Namdeo *et al.* (2003) tried addition of nitrogen enriched phosphocompost to supply phosphorus on equal P_2O_5 basis. Use of phosphocompost along with 90 kg nitrogen ha^{-1} produced grain yield higher than the recommended dose of fertilizer and it not only substituted the use of phosphatic fertilizer in wheat and soybean crops but, also saved 25 per cent of recommended dose of N without any decline in productivity of crops.

The mean yield level of RPP (7924 kg ha^{-1}) was on par with compost + NOCU + PK fertilizers. Radhakrishna *et al.* (1995) also reported that application of phospho-compost at the rate of 60 kg P_2O_5 ha^{-1} equivalent was found to produce similar grain and straw yield in ragi as obtained with recommended fertilizer P used as super phosphate. The lowest yield was observed in the treatment 'compost alone' applied plots, indicating that rate of NPK release from compost does not match the nutrient requirement rate of maize crop. So the organic nutrient sources alone are insufficient to get good yields.

The uptake of nitrogen in maize significantly increased due to application of different enriched composts (Table 3). The magnitude of increase in the uptake of nutrients was proportional to grain yield. Application of compost+ NOCU + PK fertilizers recorded significantly higher total nitrogen uptake by maize (210.8 kg ha^{-1}) compared to compost alone (68.0 kg ha^{-1}). Nitrogen uptake in Compost+ neem cake +PK fertilizers enrichment method was on par with RPP (175.2 kg ha^{-1} and 166.2 kg ha^{-1}, respectively). Red earth enrichment significantly increased the total N uptake but it was not in appreciable amount. The increase in N uptake by maize can be attributed to slow release nature of nitrogen from NOCU and supply of available nitrogen to crop for a longer period. These findings

Table 2. Grain and stover yield of maize as influenced by different methods of compost enrichment

Treatments	Grain yield (kg ha^{-1})		
	Compost without RE	Compost with RE	Mean
Compost alone	3675	4601	4138
RPP (Recommended NPK + compost)	7453	8395	7924
Compost enriched with recommended NPK fertilizers	7490	7422	7456
Compost + NOCU + PK fertilizers	8425	8826	8626
Compost enriched with neem cake + PK fertilizers	7314	7994	7654
Mean	6871	7448	-
For comparing means of	S.Em.±	C.D. (0.05)	
Red earth levels (A)	194	576	
Compost enrichment methods (B)	306	911	
A x B	434	1289	

Table 3. Total nitrogen, phosphorus and potassium uptake by maize as influenced by different methods of compost enrichment

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
	Compost without RE	Compost with RE	Mean	Compost without RE	Compost with RE	Mean	Compost without RE	Compost with RE	Mean
Compost alone	54.5	81.6	68.0	19.6	28.5	24.0	64.2	97.0	80.6
RPP (Recommended NPK + compost)	153.2	179.2	166.2	46.7	55.8	51.2	152.4	178.4	165.4
Compost enriched with recommended NPK fertilizers	163.0	167.7	165.3	50.5	51.8	51.1	158.4	167.8	163.1
Compost + NOCU + PK fertilizers	202.8	218.9	210.8	62.3	68.6	65.4	194.7	216.9	205.8
Compost enriched with neem cake + PK fertilizers	164.7	185.7	175.2	50.3	56.2	53.2	158.7	174.2	166.5
Mean	147.6	166.6		45.8	52.2		145.6	166.8	
For comparing means of	S.Em.±	C.D. (0.05)		S.Em.±	C.D. (0.05)		S.Em.±	C.D.(0.05)	
Red earth levels (A)	3.84	11.42		1.18	3.52		5.60	16.66	
Compost enrichment methods (B)	6.07	18.06		1.87	5.57		8.86	26.35	
A x B	8.59	25.54		2.65	7.88		12.54	37.26	

RPP- Recommended package of practices, NOCU- neem oil coated urea, RE- red earth

are in agreement with that of Ahmad *et al.* (2008). The higher P uptake was observed in compost+ NOCU+ PK fertilizers (65.4 kg ha^{-1}) followed by compost + neem cake + PK fertilizers enrichment method (53.2 kg ha^{-1}). This may be ascribed to higher availability of P in soil due to their addition through NPK fertilizer and FYM and also release of these nutrients from native sources in soil as a result of increased biological activity. The findings are similar to those obtained by Nishanth and Biswas (2008). The highest K uptake was observed in compost+ NOCU+ PK fertilizers (205.8 kg ha^{-1}), followed by compost + neem cake +PK fertilizers enrichment method (166.5 kg ha^{-1}). This could be due to positive correlation between N and K. These findings are in agreement with that of Briguvanshi (1988).

The highest nitrogen use efficiency (NUE) of 34.5 kg grain per kg N applied was recorded in the compost + NOCU + PK fertilizers treatment (Table 4). With RPP, the N use efficiency was only 24.9 kg grain per kg N applied. The process of hydrolysis and nitrification of urea fertilizers are to a large extent completed in about 15-20 days and significant fraction of N likely to be leached beyond the root zone. Thus, it is natural that when neem oil coating is used as nitrification inhibitor, there is better N use efficiency. Literature reveals that neem oil which contains nimbin, nimbinin, and other tetranortriterpenoids is a potential nitrification inhibitor (Bringi, 1987). The compost + NOCU + PK fertilizers treatment recorded highest P (59.9 kg grain per kg P applied) and K (118.1 kg grain per kg K applied) use efficiency both of which were significantly superior to other treatments. Compost+ neem cake +PK fertilizers method was the next best recording with 32.0, 46.8 and 92.5 kg grain per kg of N, P and K applied, respectively. The lowest was recorded in compost enriched with recommended NPK fertilizers (22.1, 44.2 and 87.3 kg grain per kg NPK). The improvement in P and K use efficiency highlights the positive relationship between the three major nutrients N, P and K.

Available nutrient status in soil after the harvest of maize significantly increased due to different compost enrichment methods (Table 5). Compost+ neem cake +PK fertilizers enrichment method recorded significantly higher available nitrogen (192.5 kg ha^{-1}) in soil over RPP (154.8 kg ha^{-1}). This was followed by compost enriched with recommended NPK fertilizers (189.8 kg ha^{-1}) which was on par with compost + NOCU + PK fertilizers (185.2 kg ha^{-1}). Only compost applied method

Table 4. Nutrient use efficiency of maize as influenced by different methods of compost enrichment

Treatments	N (kg ha^{-1} N applied)			P (kg ha^{-1} N applied)			K (kg ha^{-1} N applied)		
	Compost without RE	Compost with RE	Mean	Compost without RE	Compost with RE	Mean	Compost without RE	Compost with RE	Mean
Compost alone	-	-	-	-	-	-	-	-	-
RPP (Recommended NPK + compost)	25.2	24.7	24.9	50.4	50.6	50.5	99.3	99.8	99.6
Compost enriched with recommended NPK fertilizers	25.4	18.8	22.1	50.8	37.6	44.2	100.3	74.2	87.3
Compost + NOCU + PK fertilizers	36.5	32.5	34.5	63.4	56.3	59.9	125	111.2	118.1
Compost enriched with neem cake + PK fertilizers	33.1	30.8	32.0	48.5	45.2	46.8	95.7	89.3	92.5
Mean	30.0	26.7		53.2	47.4		105.0	93.6	
For comparing means of	S.Em.±	C.D. (0.05)		S.Em.±	C.D. (0.05)		S.Em.±	C.D. (0.05)	
Red earth levels (A)	1.9	NS		3.4	NS		6.8	NS	
Compost enrichment methods (B)	2.7	8.3		4.9	14.7		9.6	29.4	
A x B	3.8	11.7		6.9	20.8		13.6	41.6	

Table 5. Available nitrogen, phosphorus and potassium status in soil after harvest of maize as influenced by different methods of compost enrichment

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
	Compost without RE	Compost with RE	Mean	Compost without RE	Compost with RE	Mean	Compost without RE	Compost with RE	Mean
Compost alone	137.7	141.3	139.5	24.6	26.0	25.3	132.7	137.1	134.9
RPP (Recommended NPK + compost)	152.3	157.3	154.8	33.3	34.2	33.7	157.0	165.8	161.4
Compost enriched with recommended NPK fertilizers	186.0	193.6	189.8	35.4	36.3	35.8	169.4	183.4	176.4
Compost + NOCU + PK fertilizers	181.3	189.0	185.2	34.3	34.6	34.4	161.6	168.2	164.9
Compost enriched with neem cake + PK fertilizers	190.0	195.0	192.5	37.3	38.0	37.6	177.7	186.7	182.2
Mean	169.5	175.2		33.0	33.8		159.7	168.2	
For comparing means of	S.Em.±	C.D.(0.05)		S.Em.±	C.D.(0.05)		S.Em.±	C.D.(0.05)	
Red earth levels (A)	1.09	3.25		0.29	NS		1.01	3.02	
Compost enrichment methods (B)	1.73	5.14		0.47	1.39		1.60	4.78	
A x B	2.61	7.87		0.66	1.97		2.27	6.76	

RPP- Recommended package of practices, NOCU- neem oil coated urea, RE- red earth

recorded lowest nitrogen (139.5 kg ha^{-1}). The increase in the nitrogen status of soil could be due to reduced leaching and volatilization losses of nitrogen by enriched compost. There was no appreciable increase in available nitrogen with the use of red earth enriched compost. These results are in agreement with those obtained by Hebbi (2000). Compost + neem cake + PK fertilizers enrichment method recorded significantly higher available phosphorus (37.6 kg ha^{-1}) and available potassium (182.2 kg ha^{-1}) in soil over RPP (33.7 kg ha^{-1} and 161.4 kg ha^{-1}, respectively). This was followed by compost enriched with recommended NPK fertilizers (35.8 kg ha^{-1} and 176.4 kg ha^{-1} of available phosphorus and potassium, respectively). The enriched compost increases microbial activity in soil which might have helped in mineralizing P from organic pools in soil. Similar findings were reported by Nishant and Biswas (2008).

Use of compost enriched with neem oil coated urea along with red earth significantly increased the maize grain yield over presently recommended package of practices of applying only NPK fertilizers. Use of compost enriched with neem oil coated urea along with red earth recorded highest N uptake with better N use efficiency for every kg fertilizer N used.

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