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Agronomy

Influence of Vermicompost application alongwith Nitrogen on Growth, Nutrients uptake, Yield Attributes and Economics of Rice (*Oryza sativa L.*)

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Abstract

A field experiment was conducted to study the effect of vermicompost application on growth, nutrients uptake, yield attributes and economics of rice (variety ADT 43) at Agricultural College and Research Institute, Madurai during kharif season. Five main plot treatments *viz.*, M_1 - control, M_2 - farmyard manure @ 12.5 t ha^{-1}, M_3 - vermicompost @ 1.5 t ha^{-1}, M_4 - vermicompost @ 2.0 t ha^{-1} and vermicompost @2.5 t ha^{-1} and three sub plot treatments viz., S_1 – leaf colour chart critical value less than 3, S_2 - leaf colour chart critical value less than 4 and S_3 - Recommended dose of nitrogen were replicated thrice in a split plot design. The results revealed that growth and growth attributes, yield attributes, N, P and K uptake and benefit :cost ratio were recorded higher under application of vermicompost at the rate of 2.5 t ha^{-1} along with nitrogen addition based on leaf colour chart critical value less than 4. Application of vermicompost @ 2.5 t ha^{-1} along with nitrogen addition based on leaf colour chart critical value less than 4 was registered highest benefit cost ratio of 2.14 when compared to control was 1.83.

Highlights

Overall findings on growth attributes, yield attributes, nutrients uptake and B:C ratio were recorded highest under application of vermicompost with nitrogen through LCC <4

Keywords: Organic manure, growth parameter, yield attributes, NPK uptake, B: C ratio

Rice is global grain as almost grown in 89 nations and it is stable food for more than half of the global population. Rice has been supporting more people for many years than any other cereals. Rice is one of the three most important food crops in the world, forms the stable diet of 2.7 billion people. Fertilizers are the major sources of nutrients for rice under intensive cultivation. However, imbalanced use of fertilizers in India has brought in its wake many soil fertility problems. Organic matter in soil influences almost all the components of soil linked with crop production (Bhatt *et al*., 2012). Application of vermicompost to crops like rice, which require standing water, is beneficial for increasing yield. The thick, dark green leaves within 15 days after application of vermicompost can be taken as marker character in indicating the effect of vermicompost. Vermicomposting is one such viable technique for augmentation of organic source in soil. Application of vermicompost influences the physical, chemical and biological properties of soil. It improves the water holding capacity of the soil. It posses vitamins and growth hormones which have a direct role on plant growth. Thus it plays an important role in building up of nutrients in soil and there by sustaining the growth and yield attributes of rice. Integrated use of organic N through vermicompost and fertilizer N enhanced the growth and yield attributes of wet land rice Hasanuzzaman *et al.*, 2010. Chittapur *et al.*, (2005) reported that the higher N, P and K uptake were recorded with vermicompost application with N management at LCC-3 in Dodiga than other treatment combinations and the control. Sharma *et al.* (2007) reported that the N and P uptake by grain and straw increased significantly with increasing levels of nitrogen up to 120 kg ha^{-1} and P uptake by grain and straw increased significantly up to 80 kg ha^{-1}. Rajni Rani and Srivastava (2001) found that supplying one third or one fourth of N as vermicompost increased plant height and yield components of rice. Roy and Singh (2006) reported that highest number of productive tillers, panicle length, filled grain and test weight were recorded with 10 t ha^{-1} vermicompost this was due to microbial stimulation effect of vermicompost and N supplied though gradual mineralization. Furthermore, ecological and environment concerns over the increased and indiscriminate use of inorganic fertilizers stressed the need to identify the optimum dose of chemical fertilizer with organic manure is required to maintaining adequate supply of nutrients for sustainable crop growth and reduced environmental pollution. Keeping these points in view, the present study was undertaken to evaluate the effect of vermicompost application on growth, nutrients uptake, yield attributes and economics of rice.

Materials and Methods

The field experiment was carried out with five main plot treatments viz., M_1- control, M_2 - farmyard manure @12.5 t ha^{-1}, M_3- vermicompost @ 1.5 t ha^{-1}, M_4 - vermicompost @ 2.0 t ha^{-1} and vermicompost @ 2.5 t ha^{-1} and three sub plot treatments viz., S_1 – leaf colour chart (LCC) critical value less than 3, S_2 - leaf colour chart critical value less than 4 and S_3- Recommended dose of nitrogen, Agricultural College and Research Institute, Madurai, during kharif season. The experiment was conducted in split plot design with three replications. Farmyard manure and various levels of vermicompost were assigned to main plot where as LCC critical value less than 3, LCC critical value less than 4 and recommended dose of N fertilizer allotted to sub plot. P and K were applied to all treatments as per the recommended dose of fertilizer @ 40:40 Kg ha^{-1}. Field observations such as plant height, number of tillers and number of productive tiller were recorded at active tillering and panicle initiation stages of rice. Thousand grain weight and number of filled grain per panicle were registered after harvest of rice crop. Nitrogen, phosphorus and potassium uptake were calculated from multiplication of nutrient content and dry matter production. Finally Benefit cost ratio was calculated by dividing the gross return with cost of cultivation as follows

$$\text{Benefit cost ratio} = \frac{\text{Gross return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

Results and Discussion

Plant height

The vermicompost @ 2.5 t ha^{-1} applied treatments observed highest plant height of 38.8 and 74.3 cm at active tillering and panicle initiation stages respectively which were followed by vermicompost @ 2 t ha^{-1} applied treatment of 36.9 and 69.8 cm at both the stages respectively (Table 1). The increased plant height is ascribed to applied vermicompost it might have accelerated the metabolic and physiological activity of the plant and put up more growth by assimilating more amounts of major nutrients and ultimately increased the plant height. These results are in close conformity with finding of Hiradeve *et al.*, (2011). The plot received with the LCC critical value less than 4 recorded the highest plant height of 40.2 and 70.9 cm at active tillering and panicle initiation stages respectively which was followed by recommended dose of N of 38.5 and 69.3 cm at both stages of rice (Table 1). The optimum nitrogen application through LCC might be the major reason and it influenced the plant height at the right time. Positive correlation between plant height and N levels has been earlier reported by Moraditochaee *et al.*, (2011). The interaction effect was found to be significant, combined application of vermicompost @ 2.5 t ha^{-1} and N based on LCC critical value less than 4 registered highest plant heights. This may be due to increased nutrient availability in soil through vermicompost and N addition.

Number of tillers

The application of vermicompost @ 2.5 t ha^{-1} showed more number of tillers of 9.6 and 16.5 followed by vermicompost @ 2 t ha^{-1} of 9.1 and 15.7 at active tillering and panicle initiation stages of rice crop (Table 1). This might be due

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to vermicompost application which caused dual benefits of improving the physical environment of rhizosphere region and adequate supply of available nutrients to the plant. The similar results were also observed by Roy and Singh (2006).The N level based on LCC critical value less than 4 recorded more number of tiller of 9.3 followed by recommended dose of N of 8.7 at active tillering and panicle initiation stages (Table 1). The nitrogen was the main nutrient in producing the vegetative growth and the tillers for the crop which was successfully supplied through LCC and split application of N resulted in more number of tillers as compared to a single application (Fallah, 2012).

Table 1: Effect of vermicompost application along with nitrogen on plant height (cm) at active tillering and panicle initiation stage of rice

Treatments	Plant height (cm)		No. of tillers	
	AT stage	PI stage	AT stage	PI stage
Organic manures				
M_1 - Control	33.9	64.1	8	13.8
M_2 - FYM@12.5 t ha^{-1}	35.7	67.7	8.3	14.2
M_3 - Vermicompost @ 1.5 t ha^{-1}	34.9	65.9	8.5	14.7
M_4 - Vermicompost @ 2.0 t ha^{-1}	36.9	69.8	9.1	15.7
M_5 - Vermicompost @ 2.5 t ha^{-1}	38.8	74.3	9.6	16.5
C.D. at 0.05 %	0.07	0.15	0.03	0.04
N levels				
S_1 - LCC critical value 3	34.4	65	8.2	14.2
S_2 - LCC critical value 4	40.2	70.9	9	15.5
S_3 - RD of N @ 120 Kg ha^{-1}	38.5	69.3	8.8	15.2
C.D. at 0.05 %	0.03	0.06	0.01	0.01
M*S (C.D. at 0.05 %)	0.09	0.18	0.03	0.05
S*M (C.D. at 0.05 %)	0.06	0.12	0.01	0.03

Number of productive tillers

The number of productive tiller is the important factor; it mainly contributes to grain yield as the number of productive tillers equal to number of panicles. The number of productive tiller increased by the addition of vermicompost @ 2.5 t ha^{-1} was registered of 11.3 followed by vermicompost @ 2 t ha^{-1} of 9.8 and FYM @ 12.5 t ha^{-1} of 8.9 (Table 2). This is due to greater availability of nutrients from applied vermicompost and N fertilizer and microbial stimulation effects of vermicompost and gradual mineralization of N (Roy and Singh, 2006). The N application based on LCC critical value less than 4 showed that more number of productive tillers of 9.3 followed by recommended dose of N of 8.7 (Table 2). This may be due to increasing levels of N and sink capacity, which ultimately resulted in increasing the productive tiller at high fertility status. Yosef Tabar (2012) also reported similar results for number of productive tillers in rice. The application of vermicompost and N based on LCC critical value less than 4 recorded more of productive tiller. This may be due to increased nutrient availability in the soil through vermicompost and N application.

Thousand grain weight

The most significant attribute of yield is thousand grain weights where the change of individual grain weight will make the variations in yield. Vermicompost application @ 2.5 t ha^{-1} recorded higher thousand grain weight of 17.58g which was on par with vermicompost application @ 2 t ha^{-1} of 17.33 gram (Table 2). This might be due to the vermicompost with higher rate of soil application helped in maintaining higher amount of nutrient availability and better absorption of nutrient by plant. These similar results were also reported by Meena (1992). The highest thousand grain weight was showed in LCC critical value less than 4 of 17.73 g which was followed by recommended dose of N of 17.16 g (Table 2). This finding was similar with findings of Singh *et al.* (2013). The interaction effect was found to be non significant.

Table 2: Effect of vermicompost application along with nitrogen on number of productive tillers, thousand grain weight and number of filled grain per panicle of rice

Treatments	No. of productive tillers	Thousand grain weight (g)	No. of filled grain
Organic manures			
M_1 - Control	6.3	15.94	87
M_2 - FYM@12.5 t ha^{-1}	8.9	17.03	91
M_3 - Vermicompost @ 1.5 t ha^{-1}	7.2	16.68	93
M_4 -Vermicompost @ 2.0 t ha^{-1}	9.8	17.33	96
M_5 - Vermicompost @ 2.5 t ha^{-1}	11.3	17.58	99
C.D. at 0.05 %	0.08	0.81	0.17
N levels			
S_1- LCC critical value 3	8	15.76	90
S_2- LCC critical value 4	9.3	17.73	96
S_3- RD of N @ 120 Kg ha^{-1}	8.7	17.16	94
C.D. at 0.05 %	0.01	0.53	0.05
M*S (C.D. at 0.05 %)	0.08	NS	0.19
S*M (C.D. at 0.05 %)	0.03	NS	0.1

Number of filled grain per panicle

The filled grain number was increased by the application of different levels of vermicompost and their interaction with different N levels based on LCC, It clearly indicated

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that the treatments could have favoured the increase in number of filled grains in turn which increased the yield. This is also due to increased uptake of nutrients as a result of enhanced availability in the soil. The similar findings were also reported by Roy and Singh (2006). Highest number of filled grain was registered by vermicompost @ 2.5 t ha^{-1} of 99 followed by vermicompost @ 2 t ha^{-1} of 96 (Table 2). This may be due to microbial stimulation effect of vermicompost and N supplied through gradual mineralization. The N application through LCC critical value less than 4 observed highest number of filled grains of 96 followed by recommended dose of N fertilizer of 94 (Table 2). The N doses have to be applied only after careful assessment of plant requirement through LCC and not by predetermined crop calendar timing. Because the need based application can help in increased filled grain percent. Similar results were also reported by Singh *et al*., (2010) who revealed that increased effect of nitrogen on growth and root production, result in greater uptake of nutrients, which increased the number of panicles, panicle mass and grains per panicles of rice.

Nitrogen, phosphorus and potassium uptake in grain and straw

The data obtained on nitrogen removal by rice grain and straw were highest of 74.6 and 39.5 kg N ha^{-1} in vermicompost application @ 2.5 t ha^{-1} which was on par with vermicompost application @ 2 t ha^{-1} of 69.6 and 35.8 kg N ha^{-1} and FYM @ 12.5 t ha^{-1} of 65 and 32.6 kg N ha^{-1} respectively (Fig. 1). The increased N uptake in the vermicompost applied plot might be due to its highest N content, mineralization of N from organic matter and mineralization effect upon native nitrogen (Sims, 1987). The N addition based on LCC critical value less than 4 registered highest N removal by the rice grain and straw of 70.2 and 36.2 kg N ha^{-1} followed by recommended dose of N of 66.7 and 34.1 kg N ha^{-1} (Fig 1). There was an increased concentration of N in grain and straw due to graded levels of N application. This may be ascribed to increase in N absorption by plant. These findings corroborate the findings of Bezbaruha *et al.*, (2011) who reported that higher nitrogen uptake with the application of nitrogen fertilizer might be due to higher nutrient concentration along with higher biomass production. The combined application of vermicompost along with N recorded significantly highest N uptake by the rice grain and straw may be due to increased availability of nutrients in soil through vermicompost and N addition.

The P uptake by rice grain and straw were recorded highest of 19.8 and 14.8 kg P ha^{-1} in application of vermicompost @ 2.5 t ha^{-1} which was on par with vermicompost application

@ 2 t ha^{-1}.and FYM @ 12.5 t ha^{-1} (Fig 2). The increased P uptake by coupled with its higher P content in grain and straw by the application of vermicompost might be due to its solubilization effect on the native phosphorous. This is in confirmation with the views of (Dahiya and Singh, 1980). The N addition based on LCC critical value less than 4 registered the highest P uptake of 18.8 and 13.4 kg P ha^{-1} followed by recommended dose of N (Fig. 2). The synergistic effect that existed between N and P would have promoted P content in grain and straw due to increased N content. The split application provides a steady availability of N that promotes the translocation of P from the vegetative organs to the grain which might be increased P content of rice grain and straw. This is close conformity with the findings of Bi *et al.*, (2012).

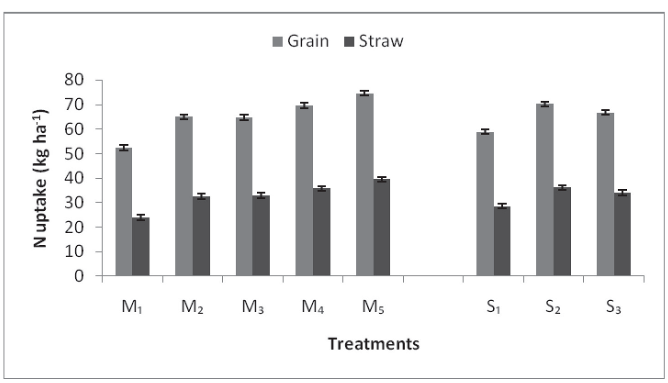

Fig. 1: Influence of vermicompost application along with nitrogen on nitrogen of rice grain and straw (kg ha^{-1})

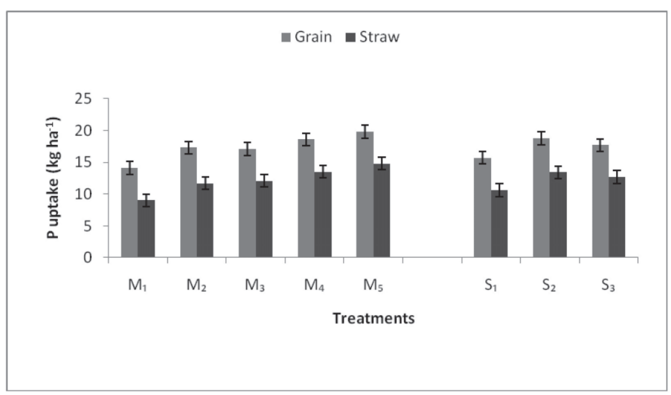

Fig. 2: Influence of vermicompost application along with nitrogen on phosphorus uptake of rice grain and straw (kg ha^{-1})

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The data indicated that K uptake by rice grain and straw were observed highest of 41.7 and 25.4 kg K ha^{-1} in application of vermicompost @ 2.5 t ha^{-1} which was on par with vermicompost application @ 2 t ha^{-1} (Figure 3). This could be attributed to higher nutrient K content and better availability of nutrient K ion from the vermicompost and also available nutrient content of vermicompost as well as their rate of release were much higher over other treatments (Goswami, 1996). The N addition based on LCC critical value less than 4 noticed highest K uptake of 39.2 and 23.4 kg K ha^{-1} followed by recommended dose of N (Figure 3). An increasing trend of K in grain and straw may be due to applied N release more $NH4^+$ -N and NO_3^- -N in soil which may occupied the selective exchange sites in the 2:1 layer clay minerals and replaced the K^+ from exchange sites thereby K registered the highest available K in soil solution concentration leading to higher absorption by rice. It may be due to similar ionic radii of both N and K ions. This was supported by Ravichandran and Sriramachandrasekharan (2011). Combined application of vermicompost and N addition based on LCC critical value less than 4 noticed significantly highest K removal by the rice grain and straw. Interaction effect between the vermicompost and nitrogen was significantly different for N, P and K removal by the rice grain and straw.

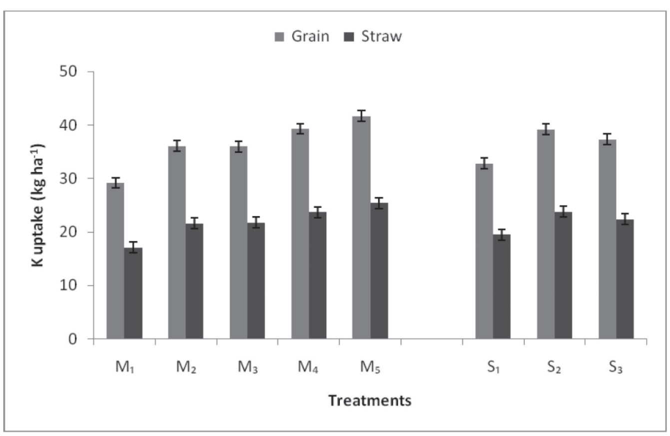

Fig. 3: Influence of vermicompost application along with nitrogen on potassium uptake of rice grain and straw (kg ha^{-1})

Benefit Cost Ratio (in treatment combinations)

The benefit cost ratio, which was found to be higher (2.14) for higher level of vermicompost @ 2.5 t ha^{-1} along with N addition based on LCC critical value less than 4 followed by vermicompost @ 2.5 t ha^{-1} with recommended dose of N (2.10) (Table 3). Among the different treatment combinations, considering the profitability, it is worth to mention that vermicompost @ 2.5 t ha^{1} applied along with LCC critical value less than 4 is beneficial. The higher B: C ratio is due to higher grain and straw were obtained from higher vermicompost application with LCC critical value less than 4. The higher grain and straw yield is might be due to nutrient availability increased in soil through vermicompost application and N application through LCC. The results are in agreement with findings of Virdia *et al.*, (2011) who stated that application of vermicompost @ 2.5 t ha^{-1} along with 100 per cent nitrogen was found beneficial in terms of economics under rice cultivation.

Table 3: Influence of vermicompost application along with nitrogen on benefit Cost ratio of rice (in different treatment combinations)

Treatments	Gross income Rs. ha^{-1}	Net income Rs. ha^{-1}	B:C ratio
M_1S_1	34990	16190	1.83
M_1S_2	36041	16841	1.88
M_1S_3	35848	16448	1.85
M_2S_1	39071	18146	1.86
M_2S_2	42223	20233	1.92
M_2S_3	39393	18318	1.87
M_3S_1	37460	17460	1.88
M_3S_2	40158	19558	1.94
M_3S_3	39362	18912	1.92
M_4S_1	39033	18633	1.91
M_4S_2	42875	22225	2.07
M_4S_3	40470	19970	1.97
M_5S_1	39104	18804	1.93
M_5S_2	44434	23634	2.14
M_5S_3	43141	22591	2.1

Conclusion

The overall results of the study showed that, the application of vermicompost @ 2.5 t ha^{-1} along with nitrogen addition based on leaf colour chart critical value less than 4 and application of phosphorus and potassium at the recommended level of 40:40 kg ha^{-1} of P_2O_5 and K_2O enhances the growth parameters, yield attributes, nitrogen, phosphorus and potassium uptake by the rice grain and straw and economics of rice better than the other treatment tried in the experiment besides conserve the soil health.

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