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EFFICACY OF MINERAL NITROGEN AND ORGANIC MANURES ON GROWTH, DRY MATTER PRODUCTION AND NUTRIENT UPTAKE IN LOWLAND RICE

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Abstract

Field experiments were undertaken to study the effect of mineral nitrogen and organic manures on growth, dry matter production and nutrient uptake in rice during kharif 2007 and 2008 in sandy clay loam soil(Typic Ustifluvents) tested on N equivalence. There were fourteen treatments replicated thrice. The design was randomized block design with test crop rice *var.* ADT 43. The treatments consisted of different organics *viz.,* composted coir pith(CCP), green manures(GM), sugarcane trash compost (STC), vermicompost (VC), poultry manure (PM) and FYM applied at 100% RDN and combination of above organics @ 50% N and urea @50% N besides 100% RDN as urea and control. The results revealed that addition of organics or mineral N or both significantly improved growth, dry matter production and nutrient uptake over control. The highest growth parameters, dry matter production and nutrient uptake were recorded in combination of organics and mineral nitrogen than their individual application. Application of 50% N through organics and 50% N through mineral N recorded highest growth parameters *viz.,* plant height (94.5, 98.6 cm), no. tillers/hill (13.6, 14.1) and LAI (4.70, 4.78), DMP (4.12, 4.25 t ha^{-1}) and (6.59, 6.62 t ha^{-1}) at tillering and panicle initiation during 2007 and 2008 respectively. Among the organics alone, application of vermicompost (100%N) recorded the highest growth parameters *viz.,* plant height (88.7, 82.8cm), no. tillers/hill (10.5, 11.5) and LAI (3.92, 4.25), DMP (4.12, 4.25 t ha^{-1}) and (6.59, 6.62 t ha^{-1}) at tillering and panicle initiation during 2007 and 2008 respectively. The highest nutrient uptake (N, P, K) were registered in 50% N through vermicompost and 50% N through mineral N. With respect to organics alone, the highest N, P, K uptake were recorded in 100% N through vermicompost in both seasons.

Key words: mineral N, vermicompost, growth parameters, DMP, nutrient uptake, rice

Introduction

Rice (*Oryza sativa* L.) is the major crop of India and occupies larger cropped area of 43.77 million hectares with an annual production of 96.43 million tonnes and productivity of 2203 kg ha^{-1}. Nitrogen is one of the most yield-limiting nutrients in rice production around the world (Fageria *et al.*, 2008), and especially in tropical Asian soils and almost every farmer has to apply the costly N fertilizer to get a desirable yield of rice (Saleque *et al.*, 2004). In India about 67 percent of rice soils are estimated to be deficit in adequate nitrogen and consequently rice crop has become a major consumer of nitrogen fertilizer. The efficiency of applied nitrogen fertilizer is low, ranges from 20-25 per cent in anaerobic soil. Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Chaturvedi, 2005). Organic manures and chemical fertilizers are both important for rice cultivation. Organic manures improve the physical condition of the soil and supply limited quantities of plant nutrients through enhanced microbial activity. On decomposition, the organic matter is converted into humus in the soil. Humus promotes efficient use of nutrients supplied through fertilizers (Panda, 2006). Fertilizers, on the other hand, contain one or more plant nutrients in concentrated readily available forms. They can be so applied as to supply the nutrients needed by plants and thereby increase crop growth and yield (Panda, 2006). The use of organic manure in conjunction with or as an alternative to mineral fertilizer is receiving considerable attention (Singh and Gangwar, 2000; Saleque *et al.*, 2004; Solaiman and Rabbani, 2006). The excessive application of chemical fertilizers has made it imperative that a portion of inorganic fertilizer is substituted by recycling organic waste. Organic manure has been proven to enhance efficiency and reduce the need for chemical fertilizers. Partial N substitution through the use of organic manure demonstrated significant superiority in yield over that produced by farmers (Singh and Gangwar, 2000).Compared to chemical farming this method was self-sufficient and self-dependent as compared to modern chemical farming relying more on organic in order to assess the utility of locally available resources(Siddaram *et al.*, 2010). Under these circumstances, the present research works were designed with an attempt to evaluate different organics and mineral nitrogen for rice production tested on N equivalence.

Materials and Methods

Field experiments were conducted in Padugai series (Typic Ustifluvents) during kharif 2007 and 2008 to evaluate the effect of organics and mineral N on growth, drymatter production and nutrient uptake in rice at N equivalence. The experimental soil was sandy clay loam in texture with pH-6.80, 6.79, EC-0.32 0.31 dSm^{-1}, OC-6.09, 6.10 g kg^{-1}, CEC-24.2, 24.0 C mol (p+) kg^{-1}, available N (224.1, 226.2 kg ha^{-1}), P (14.3, 14.1 kg ha^{-1}) and K (341.5, 345.7 kg ha^{-1}) in kharif 2007 and 2008 respectively. The treatment consisted of T_1- Absolute control, T_2-Composted coir pith (CCP- 100% N), T_3- Green manure (GM-100% N), T_4- Sugarcane trash compost (STC-100%N), T_5- Vermicompost (VC-100% N), T_6-Poultry Manure (PM-100%N), T_7- Farmyard Manure (FYM-100%N), T_8- CCP(50% N) + Urea (50% N), T_9- GM(50% N) + Urea (50% N) , T_{10}- STC(50% N) + Urea(50% N), T_{11}-VC (50% N) + Urea (50% N), T_{12}- PM (50% N) + Urea(50%N), T_{13}- FYM(50% N) + Urea (50% N), T_{14}- RDF(120:60:60 N, P_2O5, K_2O Kg ha^{-1}).The N content in different organics include CCP (1.06%), GM (1.90%), STC(0.45%), VC (1.80%), PM (2.15%) and FYM (0.60%). The treatments T_2 to T_7 received 120 kg N ha^{-1} through various organics only and T_8 to T_{13} received 60 kg N ha^{-1} through various organics (50% N) and 60 kg N ha^{-1} through urea(50%N). Accordingly quantity of organics added varied depending on N content. Available nitrogen was estimated by alkaline permanganate method, available phosphorus (Watanabe and Olsen method), available potassium by flame photometer and organic carbon (wet oxidation method). Grain and straw yields were recorded at harvest. The data was subjected to statistical scrutiny to arrive at meaningful explanation for the effect of treatments on rice crop.

Results and Discussion

The findings obtained from the present study as well as relevant discussion have been presented under following headings,

Growth parameters

The different growth parameters like plant height, number of tillers and leaf area index of rice significantly influenced by different organic manures alone or mineral nitrogen alone or in combination over control (Table 1). Application of 50% N through vermicompost + 50% N through mineral nitrogen (T_{11}) recorded highest growth parameters *viz.*, plant height (98.8, 99.3cm), number of tillers/hill (12.7, 13.9) and leaf area index (4.51, 4.67) was recorded in kharif 2007 and 2008 respectively in sandy clay loam soil. It was closely followed by 50%N through poultry manure + 50% N through mineral nitrogen (T_{12}) in both the seasons. Among the organics alone, the highest growth parameters *viz.*, plant height (88.7, 82.8cm), number of tillers/hill (10.5, 11.5) and leaf area index (3.92, 4.25) was recorded in vermicompost (100%N) in kharif 2007 and 2008 respectively. The variation in plant height due to nutrient sources was considered to be due to variation in the availability of major nutrients. Significant increase in plant height might be due to greater availability and steady release of nutrients from organic sources (FYM, vermicompost and poultry manure), which perhaps enabled the recovery of plant height towards reproductive stage. Devaraju *et al.*, (1998) opined that adequate supply of plant nutrients influenced the plant height. Nitrogen increases the chlorophyll content at all growth stages as it is a constituent and might have increased the photosynthesis and resulted in increased plant height (Gill and Singh, 1985). From this study it was observed that excess application of inorganic fertilizers is not necessary to produce effective tillers if we can supplement it from organic manures. However, organic sources offer more balanced nutrition to the plants, especially micro nutrients which has caused better affectivity of tiller in plants grown with vermicompost (Miller, 2007). This result was partially supported by Rakshit *et al.*, (2008). To achieve high yield maximization of leaf area might be an important factor. The increase in leaf number as well as size due to enough nutrition can be explained in terms of possible increase in nutrient absorption capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points (Singh and Agarwal, 2001). Larger leaf area development aids in more interception of light leading to higher dry matter production (Vijayalakshmi and Nagarajan, 1994). Sufficient nutrient facilitated to plant might have maximum cell elongation or cell division rendering better size of leaves and hence the maximum leaf area index (Mirza Hasanuzzaman *et al.*, 2010).

Dry matter production:

Table 1: Growth parameters as influenced by organics and mineral nitrogen in lowland rice in sandy clay loam soil.

Treatments	Plant height(cm)		No. of tillers /hill		Leaf Area	Index
	Kharif 2007	Kharif 2008	Kharif 2007	Kharif 2008	Kharif 2007	Kharif 2008
T_1 - Absolute control	74.5	73.2	7.23	8.10	3.60	3.67
T_2 - (CCP-100% N)	76.1	75.5	8.41	9.60	3.65	3.82
T_3 - (GM-100% N)	81.7	79.6	9.70	10.73	3.81	4.19
T_4 - (CST-100% N)	76.9	76.0	8.91	9.70	3.70	3.90
T_5 - (VC-100% N)	88.7	82.8	10.52	11.57	3.92	4.25
T_6 - (PM-100% N)	87.0	81.2	10.03	10.60	3.89	4.21
T_7 - (FYM-100% N)	79.0	79.1	9.51	10.40	3.74	3.97
T_8 - CCP (50% N) + Urea (50% N)	93.1	95.8	10.42	11.23	4.02	4.29
T_9 - GM (50% N) + Urea (50% N)	96.1	97.6	11.81	12.77	4.26	4.51
T_{10} - CST (50% N) + Urea (50% N)	94.5	95.5	11.01	11.93	4.07	4.32
T_{11} - VC (50% N) + Urea (50% N)	98.8	99.3	12.72	13.90	4.51	4.67
T_{12} - PM (50% N) + Urea (50% N)	96.5	98.4	12.20	13.57	4.40	4.60
T_{13} - FYM (50% N) + Urea (50% N)	94.5	96.4	11.31	12.37	4.20	4.39
T_{14} - RDF (120:38:38 N, P_2O_5 K_2O kg ha^{-1})	97.1	98.5	12.12	13.43	4.15	4.43
C.D @ 5 %	0.88	0.70	0.22	0.30	0.02	0.04

Application of organics or mineral nitrogen or both significantly increased the dry matter production(DMP) over control in kharif 2007 and 2008 in sandy clay loam soil (Table 2). Integration of organics with mineral nitrogen recorded highest DMP over their individual application. Application of vermicompost (50%N) + mineral N (50%N) recorded highest DMP (4.12, 4.25 t ha^{-1}) at tillering and (6.59, 6.62 t ha-1) at panicle initiation in kharif 2007 and 2008 respectively. Among the organics alone, addition of vermicompost (100%N) recorded highest DMP (3.58, 3.73 t ha^{-1}) at tillering and (5.46, 5.62 t ha^{-1}) at panicle initiation in kharif 2007 and 2008 respectively. The combined application of inorganic fertilizer and organic manure could have helped in balanced availability of nutrients at all stages. Further, this might have improved the soil aggregation, higher nutrient availability and enhanced soil microbial activity resulting in congenial soil condition. As a consequent improved uptake of nutrients has led to more vegetative growth of the plants and also dry matter. Higher dry matter production was perhaps due to the higher leaf dry weight and stem dry weight recorded at different stages. This has provided more photosynthetically active leaf area resulting in higher dry matter accumulation. Apart from that, nitrogen might have involved in various physiological activities like increased photosynthetic activity and better light interception in turn resulted in higher dry matter accumulation. Kenchaiah (1997) also reported that higher growth indices recorded in paddy had a positive association with higher dry matter accumulation. Similar results were reported by Reddy (1985) and Rajeswari (1990). As nitrogen could enhance tillers production and leaf area development, naturally total dry matter production also increased with increased levels of nitrogen. The increased dry matter production might be due to the fact that nitrogen fertilization made the plants more efficient in photosynthetic activity, enhancing the carbohydrate metabolism and ultimately increasing the dry matter accumulation (Jyothi Swaroopa and Bharatha lakshmi, 2015).

Table 2: Dry matter production (t ha^{-1}) as influenced by organics and mineral nitrogen in lowland rice in sandy clay loam soil.

Treatments	DMP (Tillering stage)		DMP (Panicle initiation)	
	Kharif 2007	Kharif 2008	Kharif 2007	Kharif 2008
T_1 - Absolute control	2.52	2.70	4.37	4.42
T_2 - (CCP-100% N)	2.73	2.87	4.52	4.63
T_3 - (GM-100% N)	3.36	3.33	4.84	4.98
T_4 - (CST-100% N)	2.92	3.05	4.56	4.58
T_5 - (VC-100% N)	3.58	3.73	5.46	5.62
T_6 - (PM-100% N)	3.42	3.56	5.40	5.51
T_7 - (FYM-100% N)	3.21	3.31	4.70	4.82
T_8 - CCP (50% N) + Urea (50% N)	3.64	3.82	5.95	6.12
T_9 - GM (50% N) + Urea (50% N)	4.02	4.17	6.23	6.32
T_{10} - CST (50% N) + Urea (50% N)	3.70	3.80	6.08	6.19
T_{11} - VC (50% N) + Urea (50% N)	4.12	4.25	6.59	6.62
T_{12} - PM (50% N) + Urea (50% N)	4.09	4.21	6.31	6.47
T_{13} - FYM (50% N) + Urea (50% N)	3.81	3.92	6.19	6.20
T_{14} - RDF (120:38:38 N, P_2O_5 K_2O)	3.98	4.07	6.42	6.49
C.D @ 5%	0.37	0.30	0.38	0.39

Nutrient uptake:

Application of organics or mineral nitrogen

Table 3: Nutrient uptake (kg ha^{-1}) as influenced by organics and mineral nitrogen in lowland rice in sandy clay loam soil.

Treatments	Nitrogen uptake		Phosphorus uptake		Potassium	uptake
	Kharif 2007	Kharif 2008	Kharif 2007	Kharif 2008	Kharif 2007	Kharif 2008
T_1 - Absolute control	24.3	26.3	7.2	7.3	27.6	28.4
T_2 - (CCP-100% N)	31.4	33.0	9.1	9.3	36.3	36.5
T_3 - (GM-100% N)	49.7	47.8	13.0	13.3	54.1	55.4
T_4 - (CST-100% N)	47.7	46.1	9.8	10.0	41.2	43.6
T_5 - (VC-100% N)	56.6	56.4	15.5	15.7	59.3	60.5
T_6 - (PM-100% N)	54.8	50.3	14.8	15.0	56.1	57.5
T_7 - (FYM-100% N)	48.2	46.0	12.1	12.4	50.4	50.8
T_8 - CCP (50% N) + Urea (50% N)	60.5	55.6	14.0	14.7	62.3	64.9
T_9 - GM (50% N) + Urea (50% N)	77.4	68.3	19.0	20.2	99.4	60.2
T_{10} - CST (50% N) + Urea (50% N)	68.8	63.5	15.3	15.5	67.4	70.1
T_{11} - VC (50% N) + Urea (50% N)	82.0	87.5	20.3	21.4	115.5	119.7
T_{12} - PM (50% N) + Urea (50% N)	78.2	68.4	19.4	20.0	108.1	116.8
T_{13} - FYM (50% N) + Urea (50% N)	72.9	64.9	17.0	17.2	98.2	101.8
T_{14} - RDF	77.8	82.7	18.8	19.0	100.5	108.1
C.D @ 5 %	0.15	0.18	0.03	0.08	0.16	0.18

or both significantly increased the nutrient uptake (N, P, K) over control in kharif 2007 and 2008 in sandy clay loam soil (Table 3). Integration of organics with mineral nitrogen recorded highest nutrient uptake over their individual application. Application of vermicompost (50%N) + mineral N (50%N) recorded highest N uptake (82.0, 87.5 kg ha^{-1}), P uptake (20.3, 21.4 kg ha^{-1}) and K uptake (115.5, 119.7 kg ha^{-1}) in kharif 2007 and 2008 respectively. It was closely followed by poultry manure (50%N) + mineral nitrogen (50%N) in both the seasons. Among the organics alone, addition of vermicompost (100%N) recorded highest N uptake (56.6, 56.4 kg ha^{-1}), P uptake (15.5, 15.7 kg ha^{-1}) and K uptake (15.5, 15.7 kg ha^{-1}) in kharif 2007 and 2008 respectively. It was closely followed by poultry manure (100%N) in both seasons. The increase in N uptake could be ascribed to slow and continued supply of the nutrients, coupled with reduced N losses via denitrification or leaching, which might have improved the synchrony between plant N demand and supply from the soil (Haile *et al.*, 2012, Tilahun *et al.*, 2013). This might be due to added fertilizers, FYM, green manuring or vermicompost as a better availability source of N in soil to rice crop. This could be ascribed to the increase in the available N, P and K contents in soil resulting from the increased availability of nutrients which ultimately increased nutrient content in the plant tissues and also greater biomass production at higher rates of fertilizer application. Since the uptake of nutrient is a function of dry matter and nutrients content, the increased grain and straw yields together with higher NPK content resulted in greater uptake of these elements. (Srivasatva *et al.*, 2014). The incorporation of organic matter with soil, especially vermicompost, stimulates the activity of beneficial soil microorganisms and ensures continuous and sustainable supply of mineral nutrients, especially N, to plants which resulted higher N uptake in rice (Taheri *et al.*, 2018). Organic manures especially vermicompost enhances available P and indirectly hinders the precipitation of phosphate, which is unavailable to plants, in the pH range of 6–9 (Mkhabela and Warman, 2005) which resulted in higher P uptake in rice. The beneficial effect of application of organics have resulted in increasing exchangeable K leading to increased concentration of K in available form, thereby increasing absorption of K. Further it was due to increased CEC. The results are corrugated the findings of Raju (2004), Meek *et al.*, (2009) and Yamagatha (2009) they observed that manures improves the uptake due to less loss and less fixation of potassium in paddy soils.

Conclusion

From this study, it can be concluded that application of 50% N through vermicompost and 50% N through urea N recorded highest growth parameters, dry matter production and nutrient uptake in rice over organics alone or mineral nitrogen alone.

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