Available online at http://www.journalijdr.com

IJDR

ISSN: 2230-9926

International Journal of Development Research
Vol. 08, Issue, 08, pp. 22075-22079, August, 2018

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

DIFFERENTIAL RESPONSE OF RICE TO ORGANICS AND MINERAL NITROGEN ON GROWTH PARAMETERS, YIELD ATTRIBUTES AND YIELD IN AN USTIFLUVENTS SOIL

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ARTICLE INFO

Article History:

Received 20th May, 2018
Received in revised form
03rd June, 2018
Accepted 16th July, 2018
Published online 30th August, 2018

Key Words:

Growth parameters,
Yield attributes,
Yield, Organics,
Urea, rice.

ABSTRACT

Introduction: Field experiments were conducted for two years in sandy clay loam soil to study the effect of organic sources and mineral nitrogen on growth parameters, yield attributes and yield of rice. The treatments consisted of addition 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 integrated use of organics and urea recorded higher growth parameters like plant height, No. of tillers/hill, chlorophyll content, LAI, CGR, RGR, and NAR compared to their individual additions and control. Among the organics alone, the growth and yield parameters were more under vermicompost amended soil compared to other organics. Similar observations were observed in yield attributes like No. of panicles/m 2, No. of grains/panicle, panicle length and 1000 grain weight. However the highest growth parameters, grain yield (5067, 5050 kg ha-1) and straw yield (6490, 6398 kg ha-1) was noticed with vermicompost (50% N) + urea (50% N) which was on par with poultry manure (50%N) + urea (50%N) but superior to rest of the treatments. Rice yield was more with 100% Urea N compared to 100% RDN as organics alone. The best treatment caused 34.2% increase in grain yield over control, 1.36% over100% urea N.

Citation: Manivannan, R. and Sriramachandrasekharan, M.V. 2018. "Patients' desire and previous experience of dental bleaching", *International Journal of Development Research*, 8, (08), 22075-22079.

INTRODUCTION

Rice is a staple food and provides 43% of calorie requirement for more than 70 % of the Indian population. It occupies an area of almost 150 million hectares and production of almost 600 million mega grams annually in world (Khush, 2005). The production of rice at all India level is 89.13 million tonnes in 41.85 million hectares with productivity of 2130 kg ha^{-1}. In Tamil Nadu, the area under rice cultivation (2009-10) is 19.35 lakh hectares producing of 3113 kg ha^{-1}(Anonnymous, 2010). To meet the demands of increasing population to maintain self sufficiency the present production level of 102 million tonnes needs to be increased up to 125 million tonnes by the year 2020 (Sridevi 2011). Limited availability of additional land for crop production, along with declining yield of major food crops, have heightened concerns about agriculture's ability to feed the growing population expected to exceed 7.5 billion by the year 2020.

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Nitrogen is typically the nutrient of most concern because it has strong influence on cereal crop yields. It is mostly abundantly found in the N_2 gaseous form, 99.4% of which is found in the earth's atmosphere (Havlin *et al*., 2005). According to (Zia *et al*,. 2000),continuous use of chemical fertilizers even in balanced proportion will not be able to sustain crop productivity due to deterioration in soil health. Application of organic manures or some organic wastes alone was found useful (Ibrahim *et al.,* 1992; Alam and Shah, 2003), but integrated use of organic wastes and chemical fertilizer has proved more rewarding (Mian *et al.,* 1989, Nasir and Qureshi, 1999; Khanam *et al.* 2001). However, the use of organic manures alone might not meet the plant requirement due to presence of relatively low levels of nutrients. In order to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is necessary to use organic manures in conjunction with inorganic fertilizers (Fageria, 2001). Complementary application of organic and inorganic fertilizers increase nutrient synchrony and reduces losses by converting inorganic nitrogen to organic forms (Kramer *et al*., 2002). More recently, attention is given on the utilization of organic wastes, farm yard manure (FYM), compost, vermicompost and poultry manures as the most effective measure for the improving soil fertility and thereby crop productivity (Hossaen *et al*., 2011). In keeping the improvement of soil health and enhanced rice productivity in view, field experiments were conducted for 2 years to study the response of rice to organics and mineral N tested of N equivalence.

MATERIALS AND METHODS

Field experiments were conducted in Padugai series (Typic Ustifluvents) for two years to study the response of rice to addition of organics and mineral N tested at N equivalence. The experimental soil was sandy clay loam in texture with pH- 6.8, 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(314.6, 314.9 kg ha^{-1}in two years. 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_2O_5 ,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. Biometric observations on plant height, chlorophyll content, CGR, RGR, NAR, number of grains $panicle^{-1}$, number of panicles m^{-2}, panicle length, and 1000 grain weight were recorded. 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

Rice growth: Addition of organics or mineral N or their combinations significantly improved the growth and physiological characters of rice over control in both the years (Table 1). Combined application of organic manures and fertilizer N recorded the highest plant height, tiller number, chlorophyll content CGR, RGR and NAR compared to their individual application. Performance of vermicompost followed by poultry manure and green manure applied alone or in combination with mineral N was the best. This may be due to better growth and enhanced photosynthesis in presence of required nutrients in sufficient amount and also owing to better translocation of photosynthesis to sink because of balance nutrients of NPK in vermicompost (Banik and Sharma 2009). The highest plant height due to vermicompost might be due to presence of some plant growth promoters in worm casts (Tharmaraj *et al* 2011).Vermicompost stimulates the plant growth possibly through supplying nutrients and increasing chlorophyll which consequently improves the photosynthesis or through having such plant hormones as auxin and cytokinin (Ievinsh, 2011). The chlorophyll content ranged from 2.29 to 2.94mg/100g and 2.34 to 2.98 mg/100g in two years. The highest was recorded in Vermicompost with mineral nitrogen 2.94, 2.98 mg/100g) in two years. Higher chlorophyll content enhances photosynthesis rate and carbohydrate production which in turn increases 1000 grain weight, no. of grains, leaf number per plant in rice (Tejada and Gonzalez, 2009). Number of tillers $hill^{-1}$ be ranged from 9.30 to 14.96, 9.57 to14.98 (tillering stage), 9.91 to 16.01, 10.71 to 17.23 (panicle initiation) and 7.23 to 12.72, 8.10 to 13.90 (productive tillers $hill^{-1}$) in two years. The highest tiller count was noticed in vermicompost amended soil plus fertilizer nitrogen (14.96, 14.98) at tillering stage, (16.01, 17.23) at panicle initiation stage and (12.72, 13.90) productive tillers $hill^{-1}$in two years. Hasanuzzaman *et al.* (2010) reported that a significant increase in effective tillers/hill might be due to the more availability of nitrogen, which plays vital role in cell division with application of chemical fertilizer with vemicompost. The highest crop growth rate (14.7, 15.5) $gm^{-2}d^{-1}$, relative growth rate (37.1,37.5 mg g^{-1} d^{-1}), net assimilation rate (2.87,2.89 $gm^{-2}d^{-1}$) in two years was noticed with application of 50%N each through vermicompost and urea (T_{11}) and it was significantly superior to rest of the treatments. The excellent plant growth in vermicompost application was possibly due to some plant growth promoters in worm casts especially caused significant increase of many growth parameters, like crop growth rate and net assimilation rate (Mishra *et al.,* 2005).

Yield characters

Yield attributing characters like number of panicles m^{-2}, number of filled grains $panicle^{-1}$ and 1000 grain weightwere also significantly improved on addition of organics or fertilizer N or both over control in both the years (Table 2). The highest number of panicles m^{-2} (265.7, 260.5) was noticed in T_{11} (vermicompost 50%N) + urea- N (50%N) and was comparable with T_{12} (poultry manure 50%N + urea –N 50%N) and was significantly superior to rest of the treatments. This might be due to higher concentration of macro and micro nutrients in the vermicompost which was attributed to higher rate of N mineralization as a result of high cation exchange capacity, slow and gradual release of N could make the soil more productive over a longer period, thus enhanced the number of productive tillers m^{-2} (Sathish Kumar*et al.,*2007). Mohandas *et al.,*(2008) observed that the enhanced and continuous supply of nutrients by the enriched organics leading to better tiller production enhanced panicle length and filled grain of rice. The maximum number of grains $panicle^{-1}$ was noticed in rice plants which received combined application of vermicompost (50%N) + urea- N (50%N) (T_{11}) (179.4, 185.9) in two years and it was comparable with T_{14} (urea – N-100%N) but to rest of the treatments. Lengthened panicle was observed in T_{11} (vermicompost 50%N) + urea (50%N) – (24.6, 22.1cm) in two years and was significantly superior to rest of the treatments. Highest panicle length may be due to enhanced and continuous supply of nutrients by the vermicompost leading to better tiller production enhanced panicle length and filled grains of rice (Deytarafder *et al*., 2016). Higher nutrient concentrations in vermicompost probably helped to maintain the optimum nutrient status in the soil which improved the yield characters and yield values in rice. (Manish Kumar *et al*., 2003).

Rice yield

Data on rice yield (Table 3) showed the effect of mineral N or organics or both at N equivalence were statistically significant.

Table 1. Effect of organics and fertilizer N on the growth characters of rice

Treatments	Kharif 2007						Kharif 2008					
		Tiller No	Chlorophyll content (mg/100g)	CGR gm^2d^{-1}	RGR $mg\ g^{-1}d^{-1}$	NAR $g\ dm^2\ d^{-1}$	Plant Height (cm)	Tiller No	Chlorophyll content (mg/100g)	CGR gm^2d^{-1}	RGR $mg\ g^{-1}d^{-1}$	NAR $gdm^2\ d^{-1}$
T_1	74.5	7.23	2.29	9.5	24.5	1.35	73.2	8.4	2.34	10.4	27.6	1.44
T_2	76.1	8.41	2.40	11.2	26.8	2.23	75.5	9.3	2.49	12.3	29.4	2.26
T_3	81.7	9.70	2.54	12.2	30.4	2.23	79.6	10.9	2.65	12.9	30.1	2.37
T_4	76.9	8.91	2.43	11.0	29.0	2.12	76.0	9.9	2.53	11.7	28.8	2.12
T_5	88.7	10.52	2.67	13.0	30.4	2.55	82.8	11.8	2.72	13.7	32.2	2.59
T_6	187.0	10.03	2.63	12.4	31.3	2.56	81.2	10.7	2.70	13.3	31.5	2.56
T_7	79.0	9.51	2.50	11.8	30.8	2.44	79.1	10.5	2.60	12.4	31.2	2.45
T_8	93.1	10.42	2.68	12.0	32.9	2.59	95.8	12.1	2.72	13.9	34.5	2.60
T_9	96.1	11.81	2.81	13.5	35.6	2.68	97.6	12.8	2.90	15.0	36.0	2.72
T_{10}	94.5	11.01	2.70	12.5	33.0	2.54	95.5	11.8	2.77	13.4	34.1	2.65
T_{11}	98.8	12.72	2.94	14.7	37.1	2.87	99.3	14.1	2.98	15.5	37.5	2.89
T_{12}	96.5	12.20	2.90	13.7	35.6	2.76	98.4	13.2	2.95	15.1	36.3	2.87
T_{13}	94.5	11.31	2.76	12.9	34.7	2.68	96.4	12.9	2.80	14.2	35.4	2.70
T_{14}	97.1	12.12	2.79	14.3	35.9	2.80	98.5	12.8	2.83	15.3	36.8	2.83
CDat 5%	0.88	0.22	0.02	0.23	0.96	0.06	0.70	0.26	0.05	0.28	0.58	0.06

Table2. Effect of organics and fertilizer N on yield attributes of rice

Treatments	Kharif 2007				Kharif 2008			
	No. of panicles m^{-2}	No.of grains $panicle^{-1}$	Panicle Length (cm)	1000 grain weight (g)	No. of panicles m^{-2}	No. of grains $panicle^{-1}$	Panicle length (cm)	1000 grain weight (g)
T_1	216.3	96.9	14.3	15.8	222.1	98.2	14.8	15.3
T_2	221.3	97.4	16.4	16.1	227.2	105.2	16.6	15.7
T_3	221.4	115.4	16.9	16.5	234.8	23.1	17.2	15.8
T_4	220.1	102.4	16.1	16.1	231.2	105.7	16.9	15.6
T_5	232.3	133.4	18.4	16.5	240.1	138.1	19.0	15.9
T_6	228.3	124.1	17.8	16.4	239.8	135.4	18.8	15.8
T_7	230.2	121.3	19.3	16.3	237.4	134.3	7.7	15.7
T_8	254.2	155.8	21.3	16.2	253.5	150.1	19.0	15.8
T_9	256.4	156.4	22.8	16.4	254.8	156.6	21.0	15.9
T_{10}	251.9	153.9	21.9	16.0	251.2	154.8	19.2	15.6
T_{11}	265.7	179.4	24.6	16.3	260.5	185.9	22.1	16.1
T_{12}	262.4	175.3	23.9	16.2	256.4	183.2	21.5	15.7
T_{13}	254.4	166.2	22.6	16.4	253.7	179.2	20.4	15.8
T_{14}	255.5	170.6	23.4	16.2	265.8	181.0	21.8	15.8
CDat 5%	2.64	0.44	0.33	0.11	1.5	0.81	0.17	0.09

Table 3. Effect of organics and fertilizer on rice yield (kg ha^{-1})

Treatments	Kharif 2007		Kharif 2008	
	Grain yield	Straw yield	Grain yield	Straw yield
T_1	3776	4872	3815	4825
T_2	4253	5412	4215	5353
T_3	4606	5885	4225	5738
T_4	4349	5567	4330	5502
T_5	4672	5956	4615	5847
T_6	4629	5874	4560	5782
T_7	4443	5665	4420	5595
T_8	4717	6015	4635	6130
T_9	5022	6413	5010	6334
T_{10}	4814	6133	4765	6032
T_{11}	5067	6490	5050	6398
T_{12}	5031	6345	5015	6359
T_{13}	4913	6264	4845	6143
T_{14}	5054	6418	4982	6317
CDat 5%	55.9	58.5	21.4	23.3

Increased grain yield of rice over control (4672, 5847 kg ha^{-1}) due to 100 % N organics alone ranged from 12.6 to 23.7% and 10.5 to 20.9% in two years. Corresponding increase in the straw yield was 11.0 to 22.0 and 10.9 to 21.1%. The highest grain yield (5067, 5050 kg ha^{-1}) and straw yield (6490, 6398 kg ha^{-1}) was noticed with addition of vermicompost (50% N) and urea (50% N)-T_{11} which was on par with poultry manure (50% N) and urea (50% N)- T_{12}. On an average increase in grain yield of rice by best treatment was over 34.2% (control), 23.7% (VC -100% N alone) and 33.8% (100% N- urea). However the rice yield were lower when 100 % N applied through organics alone was compared with 100% mineral N. Higher response to the applied N was expected on this low N status experimental soil. This might be due to integration of vermicompost and inorganic fertilizers which enhances the availability of nutrients for a shorter period as mineralization of nitrogen is more rapid and in turn the losses of inorganic nitrogen due to volatalization, denitrification and leaching etc.,would be more (Ashik Jamil *et al.,* 2016). The effect of manure on increasing the number of grains $panicle^{-1}$ was more pronounced as compared to fertilizers. This might be due to more availability of macro and micronutrients from the vermicompost (Siavoshi *et al.,* 2011). The increase in grain yield of rice under vermicompost may have been due to the slow releasing nature of nutrients from the compost over a long period increases the availability of ammoniacal and nitrate nitrogen also serve in increase the efficiency of applied or native soil phosphorus due to the solublizing effect of organic acids producing during decomposition (Srivastava *et al*., 2016). It is clear that organic manure in combination with inorganic fertilizers increased the vegetative growth of plants and thereby increased straw yield of rice. Combined use of vermicompost and inorganic fertilizers help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients enhancing efficiency of applied nutrients and providing favourable soil physical conditions which ultimately increase grain yield (Gill and Walia, 2014). Improved growth coupled with transport of photosynthates towards reproductive structure might have increased the yield attributes and yield due to organic condition (Bhandari, *et al*., 2002).

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