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IMPACT OF ORGANICS AND NITROGEN FERTILIZATION ON SOIL NITROGEN FRACTIONS IN LOWLAND RICE SOILS

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ABSTRACT

Field experiments were conducted in farmer's field at kuttalam in sandy clay loam and clay loam soil to study the effect of organic sources and urea on N fractions and yield in 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 addition of organics or mineral N or both significantly improved rice yields over control in both the soils. The highest grain (4615, 5078 kg ha^{-1}) and straw yield (5847, 6746 kg ha^{-1}) were recorded in 50% N through fertilizer nitrogen (urea) + 50% N through vermicompost in both soils. Among the organics alone the highest grain (4615, 5078 kg ha^{-1}) and straw yield (5847, 6746 kg ha^{-1}) were recorded in vermicompost alone (100 % N) which was followed by poultry manure (100% N) in both the soils. Integrated use of organics and urea recorded higher concentration of ammonium and nitrate nitrogen compared to their individual addition. The N fractions (NH_4-N and NO_3-N) were more under vermicompost amended soil followed by green manure and poultry manure. The mineral N was higher at initial stages and decreased with crop growth.

Keywords: N fractions, yield, organics, urea, rice

INTRODUCTION

Rice (Oryza sativa L.) is the most imported crop in India and is also the hub of food security of the global population. At global level, rice is grown on an area of about 155.62 million ha with production and productivity of 461 million tonne and 4.09 tonne/ha, respectively. India ranks first in respect of area 44.50 million ha second in production 102.75 million tonne, only after China, but the productivity of rice is very low only 2.20 tonne ha^{-1} (Anonymous, 2012). Nitrogen (N) is the most important mineral nutrient affecting the growth and yield of crops and its adequate supply in the soil in forms which roots can take up is essential for high yields. The term "N dynamics" includes the distribution and transformation of organic and inorganic N forms as well as their atmospheric and biospheric interrelations (Stevenson 1982). Over 90% of total N occurs in organic forms in the surface layer of most soils. Soil organic N (SON) plays a key role in terms of plant nutrition through direct and indirect effects on microbial activity and nutrient availability. Knowledge about the amounts and distributions of the organic forms of N, therefore should contribute to a better understanding of the soil productivity (Bremner 1965). Inorganic N forms (mainly NH4 +-N and NO3 --N) in soils are the available forms that plants and microorganisms can use, but excess of NO3 –N can move below the root zone as water moves through it in rice fields. The efficient use of fertilizer N for crop production depends on the several transformations that fertilizer N may undergo. Judicious use of fertilizers along with organic manures affects the amounts and distribution of organic N forms in soils. Prieto *et al.,* (1997) reported that most of the added urea N was transformed into hydrolysable organic N fractions which were the major sources of plant available N. The continuous addition of organic manures along with fertilizers may stimulate mineralization and immobilization of plant nutrients (Srivastava and Lal, 1998) thereby affecting their amount in different organic and inorganic forms in soil. Understanding the effect of continuous manuring and fertilization on the transformation and behaviour of N forms is prerequisite for precise N management under intensively grown rice in lowland soils. Therefore, the present investigation was carried out to study the effect of organics and mineral nitrogen on N fractions (NH_4 - N and NO_3 – N) and their relative contribution to yield of rice.

MATERIALS AND METHODS

Field experiments were conducted in Padugai series (Typic Ustifluvents) and Kalathur series (Typic Haplusterts) to study the effect of organic sources and urea on N transformation and yield in rice tested at N equivalence. . The experimental soil was sandy clay loam (Typic Ustifluvents) and clay loam (Typic Haplusterts), pH (6.79, 8.19), EC (0.31, 0.36), available nitrogen (226.2, 227.9 kgha^{-1}), available phosphorus (14.1, 14.9 kg ha^{-1}), available potassium (345.7, 316.7 kg ha^{-1}) and organic carbon (6.10, 6.20 g kg^{-1}). The experiment was laid out in randomized block design and replicated thrice. A short duration rice variety cv. ADT 43 was chosen for both the soils. 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. Grain and straw yields were recorded at harvest. Wet soil samples were collected at tillering stage, panicle initiation and harvest stages and analyzed for ammonium and nitrate nitrogen following the standard procedure. The data was subjected to statistical scrutiny to arrive at meaningful explanation for the effect of treatments on rice crop.

RESULTS AND DISCUSSION

Nitrogen fractions

Ammoniacal Nitrogen

Application of organics alone or mineral nitrogen alone or both significantly increased the ammoniacal N at all stages of crop growth in both the soils (Table 1). At all the stages, ammoniacal nitrogen was higher in combined treatments than their individual application. Ammoniacal nitrogen decreased progressively with advancement of crop growth. at all the stages the maximum ammoniacal nitrogen was observed with application of vermicompost (50%N) + mineral nitrogen(50% N) (48.6, 39.2, 24.8 mg kg^{-1}) in sandy clay loam, (36.9, 29.6, 21.9 mg kg^{-1}) in clay loam at tillering, panicle initiation and harvest stages respectively. it was closely followed by T_9 (green manure(50%N) + mineral N(50%N) in both the soils. The best treatment caused 106.1, 190.2, 179.3% increase over control in clay loam at tillering, panicle initiation and harvest stages respectively. Among the organics alone the highest NH4-N was recorded in vermicompost (100%N) (36.3, 26.9, 20.1 mg kg^{-1}) in sandy clay loam, (31.9, 25.8, 19.2 mg kg^{-1}) in clay loam at tillering, panicle initiation and harvest stages respectively. It was closely followed by green manure and poultry manure. Addition of vermicompost and mineral nitrogen increased the NH_4-N may due to greater return of organic N to the soil by roots, root exudates and stubbles. The fertilizer combinations containing nitrogen (N, NP and NPK) also markedly increased the NH_4- N fraction of nitrogen in soil (Kusro *et al.,* 2014).

The increase in the mineral N content (NH_4 – N) of soil with the combined application of manures and fertilizers might be due to higher accumulation of organic matter and its subsequent decomposition and mineralization which contributed in accumulating higher amount of N over suboptimal treatments (Basumatary and Talukdar, 1998). The inorganic N content in unmanured control was quite low as compared to the combined use of chemical fertilizers and manure, indicating that only a small portion of the organic N is mineralized at a given point of time. The highest NH_4 -N in the plots with combined application of NPK and vermicompost which was ascribed due to increased microbial activity and resultant in enhanced nitrification process and reduction in leaching losses (Jadhao *et al.,* 2019). The conjoint use of chemical fertilizers and organic manures showed increase in amount of soil mineral N than control, obviously due to incorporation of readily available inorganic N and easily decomposable organic N (Zahoor, 2013). The increase in available N content with the incorporation organic manures may be attributed to N mineralization (NH_4-N) from organic manures (Sharma *et al* 2000). Increase in soil mineral N (NH_4-N) with the application of organic manures alone or in combination with chemical fertilizers has also been reported by Tabassum *et al* (2010).

Nitrate nitrogen

Addition of organics alone or mineral N alone or both significantly increased the NO3-N over control at all stages in sandy clay loam and clay loam soils (Table 2). The highest NO_3-N was recorded in combined treatments than their individual application in both the soils. The maximum NO_3-N was noticed in vermicompost (50%N) + mineral N (50%N) (15.87, 12.83, 11.62 mg kg^{-1}) in sandy clay loam and (15.2, 13.5, 10.9 mg kg^{-1}) in clay loam at tillering, panicle initiation and harvest stages respectively. The best treatment caused 251.1, 227.2, 325.6% increase over control at tillering, panicle initiation and harvest stages respectively. Among the organics the highest NO_3-N was recorded in vermicompost (100%N) (12.81, 9.79, 8.08 mg kg^{-1}) in sandy clay loam and (12.8, 10.2, 8.2 mg kg^{-1}) in clay loam at tillering, panicle initiation and harvest stages respectively. The increased content of NO_3-N due to vermicompost application may be ascribed to mineralization of vermicompost and its oxidation leads to a higher concentration of NO3-N content in soil (Khankhane and Yadav, 2000). The higher NO_3-N content in soil may be due to slower release of N from vermicompost resulting in smaller losses of N and building of higher concentration of NO_3-N content in soil.

Rice yield

Grain and straw yield was significantly increased due to addition of organics alone or mineral nitrogen alone or both over control in both the soils (Table 3). The highest grain and straw yield were recorded in combined treatments

Table 1. Effect of organics and mineral nitrogen on ammoniacal nitrogen (mg kg^{-1}) in sandy clay loam and clay loam soils

Treatments	NH_4 - Nitrogen(kg ha^{-1})					
	Sandy Clay loam			Clay loam		
	Tillering stage	Panicle initiation	Harvest stage	Tillering stage	Panicle initiation	Harvest stage
T_1	17.9	13.5	10.6	17.9	10.2	8.2
T_2	27.2	21.9	17.8	26.8	22.9	16.5
T_3	35.1	25.8	19.4	30.3	24.8	18.6
T_4	30.7	24.1	18.2	27.6	23.2	17.1
T_5	36.3	26.9	20.1	31.9	25.8	19.2
T_6	35.4	24.8	19.8	30.6	23.9	18.4
T_7	34.7	25.1	18.6	30.9	23.6	18.0
T_8	37.6	31.9	20.3	32.8	26.2	21.3
T_9	46.4	36.7	22.7	35.6	29.2	21.9
T_{10}	38.7	33.1	20.7	33.6	26.7	21.7
T_{11}	48.6	39.2	24.8	36.9	29.6	22.9
T_{12}	46.4	38.3	23.9	35.4	28.5	19.9
T_{13}	41.6	34.2	21.7	31.9	22.9	20.9
T_{14}	43.0	38.4	23.4	32.6	25.1	22.6
C.D @5%	0.72	0.49	0.30	0..57	0.41	0.36

Table 2. Effect of organics and mineral nitrogen on nitrate nitrogen(mg kg^{-1}) in sandy clay loam and clay loam soils

Treatments	NO_3 - Nitrogen(mg kg^{-1})					
	Sandy Clay loam			Clay loam		
	Tillering stage	Panicle initiation	Harvest stage	Tillering stage	Panicle initiation	Harvest stage
T_1	4.52	3.92	2.73	5.6	4.0	3.2
T_2	10.91	8.84	6.84	12.9	8.9	7.6
T_3	11.92	9.42	7.81	15.9	13.2	10.6
T_4	11.24	9.03	7.09	14.1	10.5	11.2
T_5	12.81	9.79	8.08	14.6	9.8	12.3
T_6	12.43	9.58	8.03	12.8	8.4	9.5
T_7	11.60	9.21	7.62	13.5	11.6	10.2
T_8	13.24	10.23	9.39	14.1	12.0	11.0
T_9	15.19	11.93	10.93	13.8	11.2	12.1
T_{10}	13.83	10.94	9.71	12.9	8.9	8.1
T_{11}	15.87	12.83	11.62	13.8	9.2	9.6
T_{12}	15.41	12.44	11.23	11.5	8.6	8.6
T_{13}	14.56	11.19	10.41	10.9	10.6	9.0
T_{14}	14.88	11.67	10.64	11.6	8.6	6.9
C.D @5%	0.46	0.07	0.05	0.46	0.50	0.36

Table 3. Effect of organics and mineral nitrogen on grain and straw yield (kg/ha) in rice in sandy clay loam and clay loam soils

Treatments	Grain Yield (kg/ha)				Straw Yield (kg/ha)			
	Sandy clay loam	% increase over control	Clay loam	% increase over control	Sandy clay loam	% increase over control	Clay loam	% increase over control
T_1	3815	–	4300	–	4825	–	6235	–
T_2	4215	10.5	4752	10.5	5353	10.9	6728	7.9
T_3	4225	18.6	4962	15.4	5738	18.9	7108	14.0
T_4	4330	13.5	4777	11.1	5502	14.0	6746	8.2
T_5	4615	20.9	5078	18.1	5847	21.1	6746	8.2
T_6	4560	19.5	4881	13.5	5782	19.8	7239	16.1
T_7	4420	15.9	4825	12.2	5595	15.9	7040	12.9
T_8	4635	21.5	5070	17.9	6130	27.0	6765	8.5
T_9	5010	31.3	5088	18.3	6334	31.2	7108	14.0
T_{10}	4765	24.9	5113	18.9	6032	25.0	7201	15.5
T_{11}	5050	32.4	5332	22.9	6398	32.6	7725	23.8
T_{12}	5015	31.4	5285	24.0	6359	31.7	7607	22.0
T_{13}	4845	27.0	5135	22.9	6143	27.3	7600	212.8
T_{14}	4982	30.6	5210	21.2	6317	30.9	7575	21.5
C.D@5%	21.4	--	91.5	-	23.3	--	104.5	--

than their individual application. Plots received with 50% N through urea + 50 % N through vermicompost (T_{11}) significantly registered the highest grain (5050, 5332 kg ha^{-1}) and straw yield (6398, 7725 kg ha^{-1}) respectively. Among the organics alone, the highest grain (4615, 5078 kg ha^{-1}) and straw yield (5847, 6746 kg ha^{-1}) were recorded in vermicompost alone (T_5) which was closely followed by poultry manure alone in both the soils. The increase in grain and straw yield due to vermicompost application could be ascribed to better mineralization leading thereby higher availability of nutrients, higher occurrence of beneficial microorganisms, growth promoting hormones, antibiotics as well as enzymes (Banik *et al.,* 2006). It is perusable that integration of organic matter with inorganic nutrient sources might have regulated balanced supply of nutrients in adequate quantities over prolonged period that ultimately resulted in increased crop yield (Srivastava *et al.,* 2014).

CONCLUSION

On the basis of foregoing results, it can be concluded that integrated use of fertilizer nitrogen (50%N) + vermicompost (50%N) significantly increased the inorganic N fractions in sandy clay loam and clay loam soils. N fractions (NH_4-N) significantly and positively correlated with rice grain yield.

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