



Response of integrated nitrogen management on the growth, yield and nutrients uptake of rice grown in different textured soils

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Abstract

Balanced use of nutrients through organic sources like poultry manure, vermicompost with nitrogenous fertilizers are prerequisite to sustain soil fertility to produce maximum crop yield. It also increases soil biodiversity and reduces environmental risks associated with synthetic fertilizer. With this background the present investigation were carried out in clay loam (Kalathur series- *Typic Haplusterts*) and sandy clay loam (Padugai series- *Typic Ustifluvents*) in farmer's holding to study the effect of organics on growth, yield and nutrients uptake in rice. The treatments consisted of T₁ – Absolute control, T₂- Composted coir pith (100% N), T₃ (green manure (100%N), T₄- Sugarcane trash compost (STC-100%N), T₅-vermicompost (100%N), T₆-Poultry manure (100%N), T₇-FYM (100%N). The results revealed that application of organics were significantly influenced the growth parameters, yield and nutrients uptake over control in rice. Application of vermicompost (50% N) + mineral nitrogen (50% N) recorded highest plant height (97.5, 99.3cm), no. of tillers/hill (14.1, 13.9), LAI (4.78, 4.67), chlorophyll content (2.99, 2.98 mg 100g⁻¹) in clay loam and sandy clay loam respectively. The highest grain (5332, 5050 kg ha⁻¹) and straw yield (7725, 6398 kg ha⁻¹) with application of vermicompost (50% N) + mineral nitrogen (50% N) in clay loam and sandy clay loam respectively. Among the organics alone, the highest grain (5078, 4615 kg ha⁻¹) and straw yield (6746, 5847 kg ha⁻¹) were recorded in vermicompost (100%N) followed by poultry manure (100% N) in both soils. Application of vermicompost (50% N) + mineral nitrogen (50% N) recorded the highest nutrients uptake viz., N (50.4, 43.7 kg ha⁻¹), P (14.7, 10.7 kg ha⁻¹, K(40, 59.8 kg ha⁻¹) in clay loam and sandy clay loam respectively. Among the organics alone, the highest nutrients uptake viz., N (34.5, 28.2 kg ha⁻¹), P (7.94, 7.83 kg ha⁻¹, K(27.8, 30.2 kg ha⁻¹) were recorded in vermicompost (100% N) followed by poultry manure (100% N) in both soils. To conclude, the efficient utilization of organic wastes which resulted in vermicompost improved the plant and soil health.

Keywords: rice, growth parameters, yield, nutrients uptake, vermicompost

Introduction

Rice (*Oryza sativa* L.) is the foremost staple food in the Asia where about 92% of the global rice is produced and consumed (Baishya *et al.* 2015) [5]. Due to the increasing world's population and heavy usage of chemical fertilizers gradually deteriorating soil health, and also severe threat to atmosphere (Krishnaprabhu and Myrtle Grace, 2017) [14]. Increasing rice yield has become the most important goal of rice production with limited land and resources. India is the second largest producer of rice after china with total production of 104 million tonnes in the year 2015-16 out of 45 M ha areas. Nitrogen is the important yield limiting nutrient that requires for the metabolic activities of rice (Sharada and Sujathamma, 2018) [22]. "N" plays an extensive role during vegetative growth of the plant it also aids in branching of root carbon allocation and increases grain yield (Ali *et al.* 2018; Anandhan *et al.* 2018) [2, 1]. Of all nutrients, rice is the most responsive to application of nitrogen (Beisenova *et al.* 2019). The excessive use of chemical N fertilizer adversely affects soil health, the environment, and crop production (Ali *et al.*, 2020) [10]. Furthermore, the overuse of N fertilization enhances plant growth (Iqbal *et al.*, 2020) [10] and decreases grain quality (Iqbal *et al.* 2021) [11] and grain yield (Zörb *et al.* 2010) [23]. Excessive N fertilization causes significant environmental issues, such as enhanced greenhouse gas emission, groundwater

contamination, and surface water eutrophication (Cai *et al.* 2018) [8]. Organic manures addition is becoming an increasingly important aspect of environmentally sound sustainable agriculture. Manure can substitute mineral fertilizer for increasing crop productivity, carbon sequestration, soil structure, and fertility, as well as reducing environmental pollution (Khan *et al.* 2019) [13]. Manure fertilization can improve the soil's physical structure, allowing it to store more water and nutrients, and thus increase crop productivity (Ibrahim *et al.* 2020) [9]. However, organic fertilizer is quite low in nutrients and its nutrient releasing ability is also slow to meet plant requirements in a short period of time, therefore manure coupled with synthetic fertilizer has been confirmed to be a better approach to improve and sustain soil fertility and crop production than sole application of manure or synthetic fertilizer. It is known that mineral and organic fertilizers strongly regulate growth processes in rice plants and contribute to the formation of its specific organs. Integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility (Sharma and Subehiya, 2014) [18].

With this perspective, the present study were carried out to study the effect of organics and mineral nitrogen on growth and yield of rice.

Materials and Methods

Field experiments were conducted in farmer's field at kuttalam in two different textured soils to study the grain yield, nutrient uptake and nitrogen use efficiency as influenced by different sources of organics and fertilizer nitrogen in rice cultivation. 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 kg ha⁻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 T₁ - Absolute control, T₂ -Composted coir pith (CCP-100% N), T₃ -Green manure (GM-100% N), T₄ -Sugarcane trash compost (STC-100%N), T₅ -Vermicompost (VC-100% N), T₆ - Poultry Manure (PM-100%N), T₇ - Farmyard Manure (FYM-100%N), T₈ - CCP (50% N) + Urea (50% N), T₉ - GM (50% N) + Urea (50% N), T₁₀- STC (50% N) + Urea (50% N), T₁₁-VC (50% N) + Urea (50% N), T₁₂- PM (50% N) + Urea (50%N), T₁₃- FYM (50% N) + Urea (50% N), T₁₄- RDF (120:60:60 N, P₂O₅, K₂O 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 T₂ to T₇ received 120 kg N ha⁻¹ through various organics only and T₈ to T₁₃ 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. The recommended dose of 120: 38: 38 kg ha⁻¹ of N, P₂O₅ and K₂O was applied. N and K₂O were

applied as per the treatment schedule in four equal splits viz., basal, tillering, panicle initiation and heading stages of rice. The entire dose of P₂O₅ was applied basally before transplanting. Efforts were taken to maintain a water level of 2.5 and 5 cm in the early and later stages of crop growth period respectively. Irrigation was withheld 10 days before harvesting. All necessary management practices were carried out as per standard recommendation for rice crop. Grain and straw yield were recorded and expressed as kg ha⁻¹.

Results and Discussion

Growth parameters

Application of organics or mineral nitrogen alone or both significantly improved the growth parameters over control (Table 1). The highest growth parameters were recorded in combined application than their individual. Plots received with 50% N through urea + 50 % N through vermicompost (T₁₁) significantly registered the highest growth parameters viz., plant height (97.5, 99.3cm), no. of tillers/hill (14.1, 13.9), LAI(14.1,13.9), chlorophyll content (2.99, 2.98 mg 100g⁻¹) in sandy clay loam and clay loam soil respectively. Among the organics alone, the highest growth parameters viz., plant height (82.2, 82.8 cm), no. of tillers/hill (11.8, 11.5), LAI (4.02, 4.25), chlorophyll content (2.53, 2.72 mg 100g⁻¹) in sandy clay loam and clay loam soil respectively. The increased available N resulted in better N uptake which in turn improved the vegetative growth as indicated by taller plants, more number of tillers and increased leaf size leading to higher leaf area index (Jat and Singh, 2017).

Table 1: Effect of organics and mineral nitrogen on growth parameters in rice

Treatments	Clay loam				Sandy clay loam			
	Plant height (cm)	No. of tillers/hill	LAI	Chlorophyll content (mg 100g ⁻¹)	Plant height (cm)	No. of tillers/hill	LAI	Chlorophyll content (mg 100g ⁻¹)
T ₁ - Absolute control	81.6	8.4	3.28	2.29	73.2	8.1	3.67	2.34
T ₂ -composted coir pith(100%N)(CCP)	92.7	9.3	3.42	2.31	75.5	9.6	3.82	2.49
T ₃ -Green Manures(100%N) (GM)	93.5	10.9	3.89	2.44	79.6	10.7	4.19	2.65
T ₂ -composted sugarcane trash(100%N) (CST)	91.9	9.9	3.61	2.38	76.0	9.7	3.90	2.53
T ₂ -Vermicompost(100%N) (VC)	95.6	11.8	4.02	2.53	82.8	11.5	4.25	2.72
T ₂ - Poultry manure(100%N) (PM)	94.1	10.7	3.97	2.48	81.2	10.6	4.21	2.70
T ₇ - FYM(100% N)	93.0	10.5	3.70	2.40	79.1	10.4	3.97	2.60
T ₈ -CCP(50%N) + Urea(50% N)	95.6	12.1	4.16	2.56	95.8	11.2	4.29	2.72
T ₉ -GM(50%N) + Urea(50% N)	96.4	12.8	4.45	2.83	97.6	12.7	4.51	2.90
T ₁₀ -CST(50%N) + Urea(50% N)	94.9	11.8	4.20	2.63	95.5	11.9	4.32	2.77
T ₁₁ -VC(50%N) + Urea(50% N)	98.6	14.1	4.78	2.99	99.3	13.9	4.67	2.98
T ₁₂ -PM(50%N) + Urea(50% N)	97.5	13.2	4.63	2.91	98.4	13.5	4.60	2.95
T ₁₃ -FYM(50%N) + Urea(50% N)	96.2	12.9	4.38	2.71	96.4	12.3	4.39	2.80
T ₁₄ -RDF(120:38:38 N,P ₂ O ₅ , K ₂ O kg ha ⁻¹)	96.7	12.8	4.58	2.79	98.5	13.4	4.43	2.83
CD @ 5%	0.61	0.26	0.32	0.44	0.70	0.30	0.04	0.05

Rice yield

Application of organics or mineral nitrogen alone or both significantly increased the growth parameters over control (Table 2). Plots received with 50% N through urea + 50 % N through vermicompost (T₁₁) significantly registered the highest grain (5332, 5050 kg ha⁻¹) and straw yield (7725, 6398 kg ha⁻¹) in clay loam and sandy clay loam respectively. Among the organics alone, the highest grain (5078, 4615 kg ha⁻¹) and straw yield (6746, 5847 kg ha⁻¹) were recorded in vermicompost (100%N) followed by poultry manure (100% N) in both soils (5050, 5332 kg ha⁻¹) and straw yield (6398,

7725 kg ha⁻¹) respectively in both soils. This might be due to adequate biomass production and better nutrient uptake which might have resulted higher grain and straw yield. Steady and adequate supply of nutrients by the enhanced biochemical activity of microorganisms coupled with more photosynthesis surface would have helped in the production of more tillers and dry matter with enhanced supply of assimilates to the sink resulting in higher yield (Vinod Kumar, *et al.* 2017). Sultana *et al.* (2015) also found that significant and consistent increase in yield with combined application of organic and mineral fertilizers.

Table 2: Effect of organics and mineral nitrogen on grain and straw yield (kg/ha) in rice

Treatments	Clay loam		Sandy clay loam	
	Grain yield(kg/ha)	Straw yield(kg/ha)	Grain yield(kg/ha)	Straw yield(kg/ha)
T ₁ - Absolute control	4300	6235	3815	4825
T ₂ -composted coir pith(100%N)(CCP)	4752	6728	4215	5353
T ₃ -Green Manures(100%N) (GM)	4962	7108	4225	5738
T ₂ -composted sugarcane trash(100%N) (CST)	4777	6746	4330	5502
T ₂ -Vermicompost(100%N) (VC)	5078	7239	4615	5847
T ₂ - Poultry manure(100%N) (PM)	4881	6748	4560	5782
T ₇ - FYM(100% N)	4825	7040	4420	5595
T ₈ -CCP(50%N) + Urea(50% N)	5070	6765	4635	6130
T ₉ -GM(50%N) + Urea(50% N)	5088	7108	5010	6334
T ₁₀ -CST(50%N) + Urea(50% N)	5113	7201	4765	6032
T ₁₁ -VC(50%N) + Urea(50% N)	5332	7725	5050	6398
T ₁₂ -PM(50%N) + Urea(50% N)	5285	7607	5015	6359
T ₁₃ -FYM(50%N) + Urea(50% N)	5135	7600	4845	6143
T ₁₄ -RDF(120:38:38 N,P ₂ O ₅ , K ₂ O kg ha ⁻¹)	5210	7575	4982	6317
CD @ 5%	91.5	104.5	21.4	23.3

Nutrients uptake

Influence of organics or mineral nitrogen alone or both significantly increased nutrients uptake (N, P, K) over control in sandy clay loam and clay loam soils respectively (Table 3). Combined application of organics and mineral nitrogen recorded highest nutrients uptake compared to organics or mineral nitrogen alone. Application of vermicompost (50% N) + mineral nitrogen (50% N) recorded the highest nutrients uptake *viz.*, N (50.4, 43.7 kg ha⁻¹), P (14.7, 10.7 kg ha⁻¹, K (40, 59.8 kg ha⁻¹) in clay loam and sandy clay loam respectively. Among the organics alone, the highest nutrients uptake *viz.*, N (34.5, 28.2 kg ha⁻¹), P (7.94, 7.83 kg ha⁻¹, K (27.8, 30.2 kg ha⁻¹) were recorded in vermicompost (100%N) followed by poultry manure (100% N) in both soils. The maximum uptake of

NPK by grain and straw was recorded with integrated treatments could be ascribed to the increase in 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. 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 (Srivastava *et al.* 2014)^[17]. Among the organics alone, the increased N uptake may be due to the fact that in lowland rice soils, vermicompost incorporation undergoes decomposition at a steady rate resulting in the release of N – NH₄⁺ into soil solution which is readily available to rice plant (Alagappan and Venkitaswamy, 2019)^[3].

Table 3: Effect of organics and mineral nitrogen on nutrients uptake (kg/ha) in rice

Treatments	Clay loam			Sandy clay loam		
	N (kg/ha)	P (kg/ha)	K (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
T ₁ - Absolute control	23.8	4.13	15.8	13.1	3.65	14.2
T ₂ -composted coir pith(100%N)(CCP)	27.5	5.67	19.9	16.5	4.66	18.2
T ₃ -Green Manures(100%N) (GM)	32.5	6.70	25.3	23.9	6.67	27.7
T ₂ -composted sugarcane trash(100%N) (CST)	29.0	5.94	21.4	23.0	4.99	21.8
T ₂ -Vermicompost(100%N) (VC)	34.5	7.94	27.8	28.2	7.83	30.2
T ₂ - Poultry manure(100%N) (PM)	32.5	7.40	26.6	25.1	7.47	28.7
T ₇ - FYM(100% N)	30.7	6.32	24.4	23.0	6.19	25.4
T ₈ -CCP(50%N) + Urea(50% N)	45.7	8.87	29.1	27.8	7.35	32.4
T ₉ -GM(50%N) + Urea(50% N)	36.3	13.26	30.3	34.1	10.12	51.1
T ₁₀ -CST(50%N) + Urea(50% N)	39.6	8.81	31.8	31.7	7.77	35.0
T ₁₁ -VC(50%N) + Urea(50% N)	50.4	14.71	40.0	43.7	10.74	59.8
T ₁₂ -PM(50%N) + Urea(50% N)	48.0	12.98	36.9	34.2	10.04	58.4
T ₁₃ -FYM(50%N) + Urea(50% N)	43.4	10.46	34.6	32.4	8.59	50.9
T ₁₄ -RDF(120:38:38 N,P ₂ O ₅ , K ₂ O kg ha ⁻¹)	45.2	12.17	35.3	41.3	9.53	54.0
CD @ 5%	1.42	0.24	0.93	0.19	0.03	0.11

Increased P availability might be due to solubilisation of native P by the organic acids produced during organic manure decomposition, thus leading to better utilization of available P. The organic manure which besides N, might have increased the soil organic P content leading to increased P availability and consequently higher P uptake of rice plants (Mahajan *et al.* 2008). The higher K uptake may be due to that quick release of N from the added vermicompost with increased availability of P through the mechanism of reduction, chelation and favourable changes in soil pH and available K which favours the uptake in rice.

Higher K uptake in rice might be due to the increase in available K which may contributed to mineralization of organic manures or solubilization of nutrients from native sources during decomposition as reported by (Shukla *et al.* 2016).

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