



Direct, residual effect of organics with supplemental inorganics on nutrient uptake and yield in rice based cropping system

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Abstract

Field experiments were conducted in farmers field at kuttalam to evaluate the organics and mineral nitrogen (100%N) on nutrient uptake and yield of rice in clay loam soil in rice – rice- pulse cropping sequence. The treatments consisted of organics viz., composted coir pith (CCP), green manures (GM), sugarcane trash compost (STC), vermi compost (VC), poultry manure (PM) and FYM applied (100%N) and combination of above organics with urea@50%N besides 100% RDN as urea and control in first rice crop. The residual effect of above organics were studied in subsequent rice crop with application of fertilizer nitrogen (100%N). Residual effect of organics and fertilizer nitrogen were studied in rice fallow blackgram in two years. The test crop were rice var. ADT 43 (kharif), ADT 38 (rabi) and ADT 3 blackgram. The results revealed that integrated use of organics or residual organics and urea alone or both recorded highest nutrients uptake and yield in rice – rice – pulse cropping sequence over control. Application of vermicompost (50%N) with mineral nitrogen (T₁₁) recorded highest nutrient uptake viz., N (49.6, 49.9 kg ha⁻¹), P (15.6, 11.3 kg ha⁻¹) and K (26.7, 49.6 kg ha⁻¹) and application of residual poultry manure with mineral nitrogen (100%) N (35.3, 26.3 kg ha⁻¹), P (11.7, 8.31 kg ha⁻¹) and K (19.7, 36.3 kg ha⁻¹ in grain and straw in kharif and rabi rice respectively. Application of residual poultry manure + fertilizer nitrogen recorded the highest nutrients uptake viz., N (38.8 kg ha⁻¹), P (7.30 kg ha⁻¹) and K (29.1 kg ha⁻¹) in rice fallow black gram. Direct application of vermicompost and mineral nitrogen (50%N) recorded highest grain (5137 kg ha⁻¹) and straw yield (7519 kg ha⁻¹) and residual poultry manure in combination with fertilizer nitrogen (100%N) recorded highest grain (4341 kg ha⁻¹) and straw yield (6926 kg ha⁻¹) in rice-rice cropping sequence in two years. Residual organics and fertilizer nitrogen recorded highest pod yield (371.4, 1943 kg ha⁻¹) in rice fallow blackgram in clay loam soils in two years. This study indicated the efficient organics and inorganics combinations to sustain soil fertility and productivity in rice based cropping system.

Keywords: rice, residual organics, mineral nitrogen, nutrients uptake, yield

Introduction

Rice-rice-pulse (Greengram/Blackgram) is the predominant cropping system of major rice growing areas of Tamil Nadu. The cropping sequence of rice-rice- pulse is practically feasible, viable, economical, eco-friendly, water saving technology for sustaining soil fertility and rice productivity. Increased use of inorganic fertilizers in crop production deteriorates soil health, causes health hazard and insecurity of quality food. Despite the past gains in rice production through chemical fertilizers, recent observations of stagnant or declining yields have raised concerns about the long term sustainability of the crop production (Khan *et al.*, 2010) [14]. Continuous use of inorganic fertilizers leads to deterioration in soil chemical, physical and biological properties, and soil health (Mahajan *et al.*, 2008) [15]. The negative impacts of chemical fertilizers, coupled with escalating prices, have led to growing interests in the use of organic fertilizers as a source of nutrients. The fact that the use of organic fertilizers improves soil structure, nutrient exchange and maintains soil health has raised interests in organic farming. In recent times, reports on organic manure as a source of plant nutrients for field crops particularly as an alternative to

chemical fertilizers in rice cultivation is also increasing (Banik *et al.*, 2006; Siavoshi *et al.*, 2011) [22]. Plants acquire nutrients from two principal sources which are the soil, (through commercial fertilizer, manure and/or mineralization of organic matter); and the atmosphere (through symbiotic N fixation) (Vance, 2001; Rahman, 2013) [26]. This is because the cereal-legume cropping systems help to minimize excessive loss of N while maximizing N use efficiency and meeting cereal-legume cropping systems in India. Improvement in the soil structure due to vermicompost or poultry manure application leads to a better environment for root development (Prasad and Sinha, 2000) [18] and also improves soil water holding capacity (Dejene *et al.*, 2012) [5]. Emerging evidence indicated that integrated soil fertility management involving the judicious use of combined organic and inorganic resources is a feasible approach to overcome soil fertility constrains (Efthimiadou *et al.*, 2010) [6]. Keeping the importance of the organic farming, this study was undertaken and used different sources of organic manures on various combinations in comparison with RDF and INM. The main objective of this study was to assess the impact of

organics and inorganics on nutrient uptake by the crops and with crop yields in the rice-rice-blackgram cropping sequence under organic farming in Cauvery delta zone in Tamil Nadu, India.

Materials and Methods

Field experiments were conducted in clay loam soil (Kalathur Series- Typic Haplusterts) in kharif and rabi seasons to evaluate the direct effect of organics and fertilizer N, residual organics and direct effect of fertilizer N and residual effect of organics and fertilizer N in rice-rice-pulse cropping system. The trials were conducted during kharif and rabi season in randomised block design with fourteen treatments replicated thrice. The test crop was rice var. ADT 43, ADT 38 for kharif and rabi season respectively. The treatment structure was T1- Absolute control, T2-composted coir pith (CCP-100%N), Green manure (GM-100% N), T4- Sugarcane trash compost (STC-100%N), T5-Vermicompost (VC-100%N), T6- Poultry manure (100%N), T7- farm yard manure (FYM-100%N), T8- CCP (50%N) +Urea (100%N), T9- GM (50%N) +Urea (100%N), T10-STC (50%N) +Urea (100%N), T11-VC (50%N) +Urea (100%N), T12-PM (50%N) +Urea (100%N), T13- FYM (50%N) +Urea (100%N), T14- RDF (150:50:50 N, P2O5,K2O kg ha⁻¹). In rabi rice all the treatments received recommended dose of 50 kg P2O5 ha⁻¹ and 50 kg K2O ha⁻¹ except control. In rabi rice no organics were applied to study the residual effect but 100%N (RDF) were applied from T8-T14. The experimental soil was clay loam in texture, pH-8.20, 8.19, EC- (0.36, 0.36) dSm⁻¹, CaCO3- (2.38, 3.36%), organic carbon (6.19, 6.20 g kg⁻¹), available nitrogen (227.0, 227.9 kg ha⁻¹), available P (14.8, 14.9 kg ha⁻¹), available K (316.2, 316.7 kg ha⁻¹). The chemical properties of soil viz., Organic carbon by (Walkley and Black, 1934), Available nitrogen (Subbiah and Asija, 1956), Available P (Watanabe and Olsen, 1965) and total nitrogen in plant samples were estimated by microkjeldahl method by using standard procedures. After harvesting of first rice crop the field was prepared with fine tilth with spade without disturbing individual plots. The nutrients uptake were calculated by multiplying the nutrient content with DMP at critical stages of crop. The grain and straw yield were registered for two seasons in rice. Residual effect of organics and fertilizer N were studied in rice fallow Black gram (ADT 3) with available soil moisture in soil without disturbing layout for two years. Foliar spray of 2% DAP was applied to all treatments except control at 45 DAS. The nutrient uptake viz., nitrogen phosphorus and potassium were calculated by multiplying the nutrient content with DMP. Seed and haulm yield were recorded for both seasons. All the datas were pooled for two years and given in results and tables.

Results and discussion

Direct effect of organics and fertilizer nitrogen in kharif rice

Application of organics or fertilizer nitrogen alone or both significantly increased the nutrients uptake over control (Table 1). Combined application of organics and fertilizer

recorded higher nutrients uptake compared to organics or fertilizer alone. The highest nutrients uptake viz., nitrogen (49.6, 49.9 kg ha⁻¹), phosphorus (15.6, 11.3 kg ha⁻¹), potassium (26.7, 49.6 kg ha⁻¹ in grain and straw respectively were recorded in 50 % N vermicompost and 50% N mineral nitrogen and was comparable with 50% N poultry manure + 50% N fertilizer N. With respect to organics alone, the highest nutrients uptake viz., nitrogen (38.4, 30.2 kg ha⁻¹), phosphorus (8.48, 6.42 kg ha⁻¹), potassium (20.1, 33.8 kg ha⁻¹) in grain and straw respectively. The enhanced N, P and K uptake in this treatments could be attributed to increased dehydrogenase activity and higher nutrients supplied by vermicompost along with inorganic fertilizer (Ramesh 2011) [17]. Jeegadeeswari *et al.* (2001) also observed that the potassium uptake by rice was increased by the application of organic manure with mineral nitrogen. Higher nitrogen uptake with the application of nitrogen fertilizer might be facilitated by higher nutrient concentration along with higher biomass production (Kriya Sunghangwise and Tidarat Tanpan, 2018). The P uptake by leaves and stem were highest with vermicompost along with N fertilizers, possibly due to solubilisation of native phosphorous in soil by the vermicompost. Moreover, the synergistic effects of N and P may have promoted P content in stem (Thirunavukkarasu & Vinoth, 2013) [24]. The data indicated that K uptake was highest with vermicompost along with N fertilizers. This could be attributed to high K content and improved availability of K ions caused by the vermicompost, and also the available nutrient content of vermicompost itself, as well as the rates of release that were much higher than with other treatments (Goswami, 1996) [9]. The increasing trend of K uptake may be due to the applied N releasing more NH₄⁺-N and NO₃⁻-N from the soil, which may occupy selective exchange sites in the 2:1 layer clay minerals and replace the K⁺ from exchange sites, so that the increased available K concentration in soil increased its absorption by rice (Thirunavukkarasu & Vinoth, 2013) [24].

Application of 50 % N vermicompost and 50% N mineral nitrogen (T₁₁) gave higher grain (5137 kg ha⁻¹) and straw yield (7519 kg ha⁻¹) and was comparable with 50% N poultry manure + 50% N through fertilizer. However the lowest grain (4872 kg ha⁻¹) and straw yield (6731 kg ha⁻¹) was noticed in T₈Composted coir pith (50%N) + fertilizer nitrogen (50%N) in rice.

Among the organics alone, the application of vermicompost (T₅) recorded highest grain yield (4840 kg ha⁻¹) and straw yield (6764 kg ha⁻¹) followed by poultry manure (T₅) in rice. Vermicompost and inorganic fertilizer might allow soil organic carbon accumulation and crop productivity in rice fields through increasing N efficiency possibly by enhanced microbial activity thereby improved the grain yield (Sharada and Sujathama, 2018) [19].

Table 1: Direct effect of organics and fertilizer nitrogen on nutrients uptake (kg/ha) and yield in kharif rice in clay loam soil

Treatments	N uptake (kg/ ha)		P uptake (kg/ ha)		K uptake (kg/ ha)		Grain yield (kg/ ha)	Straw yield (kg/a)
	Grain	Straw	Grain	Straw	Grain	Straw		
T ₁ -Absolute control	25.9	18.7	4.68	2.72	10.4	19.3	4098	6040
T ₂ - CCP-100%N	30.6	22.1	6.10	3.91	13.3	24.0	4511	6502
T ₃ - GM-100%N	35.5	28.2	7.36	5.09	18.3	29.7	4744	6912
T ₄ - CCT-100%N	31.8	23.6	6.58	3.93	14.1	26.1	4536	6530
T ₅ - VC-100%N	38.4	30.2	8.48	6.42	20.1	33.8	4840	6764
T ₆ - PM-100%N	34.9	27.6	7.70	5.90	18.2	31.8	4666	6929
T ₇ - FYM-100%N	33.5	25.2	7.13	4.36	17.7	27.5	4594	6703

T ₈ - CCP(50%)+urea(100%N)	40.8	30.1	9.02	7.40	20.9	35.3	4872	6731
T ₉ - GM(50%)+urea(100%N)	46.3	46.3	14.95	8.92	22.3	37.0	4972	7142
T ₁₀ - CST(50%)+urea(100%N)	41.3	34.9	9.02	7.35	21.2	39.2	4873	6993
T ₁₁ -VC(50%)+urea(100%N)	49.6	49.9	15.69	11.29	26.7	49.6	5137	7519
T ₁₂ -PM(50%)+urea(100%N)	46.4	45.5	14.19	9.96	24.5	46.1	5063	7379
T ₁₃ -FYM-(50%)+urea(100%N)	41.9	40.8	11.02	8.38	22.0	43.0	4894	7281
T ₁₄ -RDF(120:38:38kgha-1)	44.4	42.5	13.44	9.17	22.9	33.5	4986	7333
C.D @5%	2.07	0.68	0.21	0.11	1.60	0.52	83.8	97.1

Residual effect of organics and direct effect of fertilizer nitrogen in rabi rice

Application of residual organics and fertilizer nitrogen or alone registered higher nutrients uptake over control (Table 2). Integrated application of residual organics and fertilizer recorded higher nutrients uptake compared to residual organics or fertilizer alone. The highest nutrients uptake *viz.*, nitrogen (30.37, 26.34 kg ha⁻¹), phosphorus (11.73, 8.31 kg ha⁻¹), potassium (19.7, 36.3 kg ha⁻¹) in grain and straw respectively were recorded in residual poultry manure and 100% N mineral nitrogen which was comparable with residual poultry manure + 100% fertilizer N. With respect to organics alone, application of residual poultry manure (T₆) recorded the highest nutrients uptake *viz.*, nitrogen (12.25, 11.12 kg ha⁻¹), phosphorus (5.62, 3.60 kg ha⁻¹), potassium (11.4, 23.1 kg ha⁻¹) in grain and straw respectively. The residual poultry manure might increased the photosynthesis rate and subsequently photosynthetic partitioning towards the developing grain and ultimately increased the N uptake in rice. This might be also due to integrated application of organic and inorganic fertilizers increased the decomposition and plant use efficiency of nutrients (Almaz and Martini, 2020) [1]. Superiority of poultry manure to

provide higher nutrient concentration and uptake over other organics may be due to its higher nutrient composition and able to provide nutrients to crop at proper time with its better mineralization rate. Increase in K uptake might be due to release of nitrogen from organic manures and also to the action of organic acids which helped in release of mineral bound immobile K (Sreelatha *et al.* 2006) [12].

The highest grain and straw yield (4341, 6926 kg ha⁻¹) were recorded in residual poultry manure (50%N) + mineral nitrogen (50% N) which was followed by residual vermicompost (50%N) + mineral nitrogen (50% N) in rice. This may also be due to the availability of nitrogen and other nutrients in residual poultry manure which improved the nutrients availability and ultimately resulted in higher grain and straw yield (Syed Azam *et al.* 2017). Application of poultry manure to the soils markedly increased N ammonification (about 30 mg kg⁻¹ NH₄⁺-N), which is attributed to amounts of soluble carbohydrates, low C/N ratio and low amount of lignin, resulting in high microbial activity and thus in faster decomposition, the poultry manure applied which favoured the rice yield in succeeding crop (Griffiths *et al.* 1994) [10].

Table 2: Residual effect of organics and fertilizer nitrogen on nutrients uptake (kg/ha) and yield (kg/ha) in rabi rice in clay loam soil

Treatments	N uptake (kg/ ha)		P uptake (kg/ ha)		K uptake (kg/ ha)		Grain yield (kg/ ha)	Straw yield (kg/ha)
	Grain	Straw	Grain	Straw	Grain	Straw		
T ₁ -Absolute control	3.83	2.99	1.92	1.24	4.9	9.75	3194	4992
T ₂ - CCP-100%N	8.81	6.18	3.2	2.57	8.05	16.5	3767	5711
T ₃ - GM-100%N	7.53	5.16	2.95	2.27	6.8	14.5	3689	5819
T ₄ - CCT-100%N	10.09	6.94	3.84	2.59	8.85	17.8	3850	5779
T ₅ - VC-100%N	11.03	9.55	5.00	3.25	10.8	21.4	4007	5965
T ₆ - PM-100%N	12.25	11.12	5.62	3.60	11.4	23.1	4017	6030
T ₇ - FYM-100%N	9.39	9.1	4.10	2.61	9.75	18.9	3913	5865
T ₈ - CCP(50%)+urea(100%N)	18.21	16.86	6.75	5.17	13.2	27.9	4096	6490
T ₉ - GM(50%)+urea(100%N)	16.01	14.71	6.28	4.44	12.4	26.0	4055	6230
T ₁₀ - CST(50%)+urea(100%N)	23.21	18.94	6.99	5.63	14.7	30.8	4115	6644
T ₁₁ -VC(50%)+urea(100%N)	32.78	21.82	11.1	7.17	18.3	34.2	4284	6841
T ₁₂ -PM(50%)+urea(100%N)	35.37	26.34	11.73	8.31	19.7	36.3	4341	6926
T ₁₃ -FYM-(50%)+urea(100%N)	27.88	22.88	9.44	6.71	16.7	32.9	4199	6716
T ₁₄ -RDF(120:38:38kgha-1)	27.37	22.22	8.48	6.72	16.5	31.1	4244	6723
C.D @5%	0.15	0.05	0.06	0.04	0.07	1.19	12.2	15.8

Residual effect of organics and fertilizer nitrogen in rice fallow blackgram

Residual organics or fertilizer nitrogen alone or both on the nitrogen uptake over control (Table 3). The higher nitrogen uptake was noticed in combined application of organics and fertilizer nitrogen compared to fertilizer alone or organics alone. The higher nutrients uptake *viz.*, N (38.8 kg ha⁻¹), P (7.30 kg ha⁻¹) and K (29.1 kg ha⁻¹) were registered in poultry manure + 100% fertilizer N (T₁₂) which closely followed by vermicompost + 100% fertilizer N (T₁₁). Among the organics alone, the highest nutrients uptake *viz.*, N (30.2 kg

ha⁻¹), P (3.70 kg ha⁻¹) and K (22.4 kg ha⁻¹) were recorded in poultry manure (100% N) (T₆). This may be due to and due to the increased root development and more nutrient availability, resulting in better absorption and utilization of all plant nutrients, thus resulting in more nitrogen content in seed thereby increased the nutrients uptake in blackgram (Gajendra singh *et al.* 2016). Residual organics alone or fertilizer nitrogen alone or both significantly improved the grain yield over control in both years (Table 3). The highest grain and haulm yield (371.4, 1943kg ha⁻¹) were recorded in residual poultry manure + fertilizer nitrogen which was

closely followed by vermicompost + 100% fertilizer N (T₁₁). The increase in yield might be due to enhancement in growth and yield parameters as well as uptake of nutrients by crop. This might be due to better availability of P to blackgram when applied to preceding rice crop in kharif season (Latha *et al.* 2020) [18].

Increase in haulm yield might be due to the cumulative influence of improvement in vegetative growth of crop through the atmospherically nitrogen fixed in the root

nodules (Ghosh and Joseph 2008) [8]. The superiority of residual effect of poultry manure through efficient utilization of mineralized N from poultry manure along with atmospheric N fixed by the crop itself (by increasing the activity of nodule bacteria would have increased the availability of N throughout the growth period and thereby increased the assimilation of photosynthates which in turn better source and sink relationship led to better performance of rice fallow blackgram crop (Latha *et al.* 2020) [18].

Table 3: Residual effect of organics and fertilizer nitrogen on nutrients uptake (kg/ha) and yield in rice fallow blackgram

Treatments	N uptake (kg/ ha)	P uptake (kg/ ha)	K uptake (kg/ ha)	Grain yield (kg/ ha)	Haulm yield (kg/ha)
T ₁ -Absolute control	18.4	0.81	13.7	200.1	1152
T ₂ - CCP-100%N	24.7	2.34	18.6	326.0	1428
T ₃ - GM-100%N	23.8	1.79	18.0	359.7	1401
T ₄ - CCT-100%N	26.8	2.51	20.1	341.4	1523
T ₅ - VC-100%N	28.5	3.47	21.7	345.7	1608
T ₆ - PM-100%N	30.2	3.70	22.4	1651	1651
T ₇ - FYM-100%N	27.4	3.18	20.3	343.3	1531
T ₈ - CCP(50%)+urea(100%N	33.3	4.03	25.1	356.9	1795
T ₉ - GM(50%)+urea(100%N	31.9	4.52	24.1	353.5	1750
T ₁₀ - CST(50%)+urea(100%N	34.7	5.49	26.0	361	1835
T ₁₁ -VC(50%)+urea(100%N	37.2	6.59	27.8	369.1	1902
T ₁₂ -PM(50%)+urea(100%N	38.8	7.30	29.1	371.4	1943
T ₁₃ -FYM-(50%)+urea(100%N	36.2	6.04	27.0	363.7	1873
T ₁₄ -RDF(120:38:38kg/ha-1)	30.6	4.02	22.2	350.1	1714
C.D @5%	0.20	0.03	0.19	0.23	46.0

Conclusion

Thus from the present study, it can be concluded that application of 50% N vermicompost along with 50 % mineral nitrogen produced higher nutrients uptake and grain yield in kharif rice. Application of residual poultry manure and 100% mineral nitrogen recorded highest nutrients uptake and yield in rabi rice. The highest nutrients uptake (N, P, K), and grain yield were recorded in poultry manure and mineral nitrogen (100%N) in rice fallow blackgram.

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