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Amalgamated effect of various organics with chemical fertilizer on the performance of rice-rice-pulse sequence in typic haplusterts soil

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Abstract

Field experiments were conducted for two years at the farmer's field during kharif and rabi season at Kuttalam, Mayiladuthurai district to study the yield, nutrient uptake and nitrogen use efficiency (NUE) in rice-rice-pulse cropping system due to amalgamated effect of organics and fertilizer N in Typic Haplusterts soil. The treatments consisted of organics *viz*., composted coir pith (CCP), green manures (GM), sugarcane trash compost (STC), vermicompost (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 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 black gram also. The test crops were rice var. ADT 43(kharif), ADT 38 (rabi) and ADT 3 black gram. The results on pooled data revealed that integrated use of organics or residual organics and urea or alone recorded higher yield, N uptake and NUE in rice–rice– pulse cropping sequence over control. Direct application of vermicompost and mineral nitrogen (50%N) recorded the highest grain (5137 kg ha^{-1}) and straw yield (7519 kg ha^{-1}) and poultry manure with fertilizer nitrogen (100%N) recorded the highest (4341, 6926 kg ha^{-1}) grain and straw yield, respectively in rice-rice cropping sequence. Application of vermicompost + fertilizer N recorded the highest N uptake in grain and straw in kharif rice and poultry manure and fertilizer N (100% N) recorded the highest N uptake in rabi rice. Residual effect of poultry manure and fertilizer nitrogen recorded the highest grain yield (371 kg ha^{-1}) and N uptake in rice fallow black gram. The nitrogen use efficiencies were highest in vermicompost (50% N) + fertilizer nitrogen (50% N) in kharif rice, poultry manure + fertilizer nitrogen (100%N) in rabi rice and in rice fallow black gram.

Keywords: black gram, fertilizer nitrogen, nue, poultry manure rice, vermicompost, yield

Introduction

Rice is the most prevalent cereal crop accounting 45 per cent of the total food grain production of the country. India produced 112.91 million tonnes of rice from an area of 43.79 million ha during 2017-18 (Agricultural Statistics, 2020) [1]. Rice-rice-pulse is the predominant cropping system of major rice growing areas of Tamil Nadu. Rice cropping sequence plays a significant role in maintaining soil health and ensures in food security. Nitrogen is involved in plant physiological and biochemical processes and lower nitrogen in soils affects the rice productivity and varietal efficiency (Souri and Hatamian, 2019) [40]. Chemical fertilizer application helps in enhancing rice grain yield, which has been considered as an effective channel to address the food safety issue due to an increasing population. In recent years, the input of nitrogen fertilizer is rising rapidly and N have been overused in rice production, leading to not only environmental pollution but also an increase in production cost (Yang *et al.* 2020) [48]. This change without inputs of organic fertilizers to the soil is assumed unsustainable due to the loss of soil organic matter (Lee *et al.*, 2009, Nayak *et al.*, 2012) [29, 20]. However, the use of organic manures alone may fail to meet plant requirement due to presence of low levels of nutrients. Hence, to make the soil fertile, productive and healthy, it is necessary to use organic manures in combination with inorganic fertilizers to achieve targeted yields. Maximum rice production with sustainable manner can be achieved through integration of nutrient sources (Setiawati *et al.* 2020) [39]. Keeping these points in view, the present investigation was carried out in rice- rice-pulse cropping sequence to evaluate the amalgamated influence of organics and fertilizer nitrogen on yield, N uptake and nitrogen use efficiencies in Typic Haplusterts soil

Materials and Methods

Field experiments were conducted in clay loam soil (Kalathur Series- Typic Haplusterts) in kharif and rabi seasons for two years to evaluate the direct effect of organics and fertilizer N, residual effect organics and direct effect of fertilizer N and residual effect of organics and fertilizer N in rice-rice-pulse cropping system.. In kharif rice, the treatment structure was T_1- Absolute control, T_2- composted coir pith(CCP-100%N), Green manure(GM-100% N), T_4- sugarcane trash compost(STC-100%N), T_5- vermicompost (VC-100%N), T_6- poultry manure(100%N), T_7-farm yard 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(120:38:38 N, P_2O_5, K_2O kg ha^{-1}).In rabi rice, the treatment structure was T_1- Absolute control, T_2-

composted coir pith (CCP-100%N), Green manure(GM-100% N), T_4- sugarcane trash compost(STC-100%N), T_5-vermicompost (VC-100%N), T_6- poultry manure (100%N), T_7- farm yard manure (FYM-100%N), T_8- CCP(50%N) + Urea (100%N), T_9-GM (50%N) + Urea (100%N), T_{10}-STC (50%N) + Urea (100%N), T_{11}-VC (50%N) + Urea (100%N), T_{12}-PM (50%N) +Urea (100%N), T_{13}-FYM (50%N) + Urea (100%N),T_{14}- RDF (150:50:50 N, P_2O_5, K_2O kg ha^{-1}). All the treatments received recommended dose of 50 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1} except control. In rabi rice, no organics were applied to study the residual effect but 100% N (RDF) were applied from T_8- T_{14}. The experiment was conducted in randomized block design with three replications. The test crop was rice var. ADT 43, ADT 38 for kharif and Rabi season respectively. The experimental soil was clay loam in texture, pH- 8.20, 8.19, EC- (0.36, 0.36) dSm^{-1}, $CaCO_3$- (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) [46], Available nitrogen (Subbiah and Asija, 1956) [41], Available P (Watanabe and Olsen, 1965) [45] and total nitrogen in plant samples were estimated by microkjeldahl method following standard procedures. After harvest of first rice crop, the field was prepared with fine tilth with spade without disturbing individual plots for raising rabi crop. The grain and straw yield were recorded at harvest. Nitrogen uptake was calculated with nutrient content in grain and straw by multiplying with grain and straw yield, respectively. Their respective nitrogen use efficiencies were computed. 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. Seed and haulm yield were recorded for both seasons. The nitrogen use efficiencies *viz*., response ratio was worked out in rice fallow black gram. All the data's were pooled for two years and given in results and tables.

Results and Discussion

Rice yield

Direct effect (kharif rice)

Application of organics or fertilizer N alone or both significantly increased the grain and straw yield over control (Table 1). The pooled data showed percent increase in grain yield over control due to organics alone ranged from 10 to 18.1. The variations noticed in grain yield among the organic manures may be due to differences in nutrient composition, decomposition rate, C/N ratio (Hasanuzzaman *et al.,* 2010) [14]. Among the organics alone, the highest grain (4849 kg ha^{-1}) and straw yield (6764 kg ha^{-1}) were recorded in T_5 (vermicompost 100%N) alone. This may be due to presence of higher amount of major and micronutrients which makes the best organic source than other manures (Ramalakshmi *et al.,* 2012) [32]. The higher grain yield due to vermicompost might be due to narrow C: N ratio than other organic manures, higher activity of microbes resulted in mobilization of nutrients and thereby leads to better availability of nutrients and higher grain and straw yield (Chakravorti and Samantary, 2006 [9]. The application of compost coir pith produced least yield might be due to lower content of nutrients and higher C N ratio (Sharada and Sujathama, 2018) [34]. Lower grain and straw yield due to green manures may be slower decomposition rate, wider C/N ratio of the manure when compared to vermicompost (Singh et al. 2008) [35].

Percent increase in the grain yield due to organics and fertilizer N ranged from 18.8 to 25.3 and in straw yield ranged from 11.4 to 24.5. The variations among the integrated treatments may be due to different proportions of available nutrients and differential mineralization rate on account of C N ratio (Thiruneelakandan and Subbulakshmi, 2015) [42]. The pooled date showed application of vermicompost (50%N) + fertilizer N (50% N) recorded highest grain (5137 kg ha^{-1}) and straw yield (7519 kg ha^{-1}) followed by poultry manure (50% N) + fertilizer (50% N). The increased grain and straw yield may be due to efficient absorption of nutrients from organic manures and fertilizers that would have increased the availability of nitrogen throughout the crop growth in turn promoting the grain yield.. This was confirmed by significant positive linear relationship noticed between grain yield of rice and pulse with grain N uptake (Fig.1). 93.19 % variation in grain N uptake was explained by grain yield. Higher availability of major and micronutrients in vermicompost, their active participation in carbon assimilation and immediate release of nutrients from fertilizer N improved the yield than other manures (Datta and Singh 2010) [10]. Greater response obtained from vermicompost probably related to narrow C/N ratio, higher mineralization which influenced the nutrients uptake and thereby increased the rice yield (Mondal *et al.,* 2016) [26].

Table 1: Effect of different organics and chemical fertilizer N on yield in rice-rice-pulse #

Treatments	Direct effect (kharif)		Residual effect (rabi)*		Residual effect (rice fallow)**	
	Grain	Straw	Grain	Straw	Grain	Haulm
T_1-Absolute control	4098	6040	3194	4992	200	1152
T_2- CCP-100%N	4511	6502	3767	5711	326	1428
T_3- GM-100%N	4744	6912	3689	5819	359	1401
T_4- CCT-100%N	4536	6530	3850	5779	341	1523
T_5- VC-100%N	4840	6764	4007	5965	345	1608
T_6- PM-100%N	4666	6929	4017	6030	348	1651
T_7- FYM-100%N	4594	6703	3913	5865	343	1531
T_8-CCP(50%)+ Urea(50%N)	4872	6731	4096	6490	356	1795
T_9- GM(50%)+Urea(50%N)	4972	7142	4055	6230	353	1750
T_{10}- CST(50%)+Urea(50%N)	4873	6993	4115	6644	361	1835
T_{11}-VC(50%)+Urea(50%N)	5137	7519	4284	6841	369	1902
T_{12}-PM(50%)+Urea(50%N)	5063	7379	4341	6926	371	1943
T_{13}-FYM-(50%)+Urea(50%N)	4894	7281	4199	6716	363	1873
T_{14}-RDF(120:38:38 kg ha^{-1}) kharif/ 150: 50:50 kg ha^{-1}) Rabi	4986	7333	4244	6723	350	1714
C.D @5%	83.8	97.1	12.2	15.8	0.23	46.0

pooled data for two years * Residual effect of organics ** residual effect of organics and fertilizer N

* Organics were applied to kharif rice and rabi rice received 100% N from T_8 to T_{14}

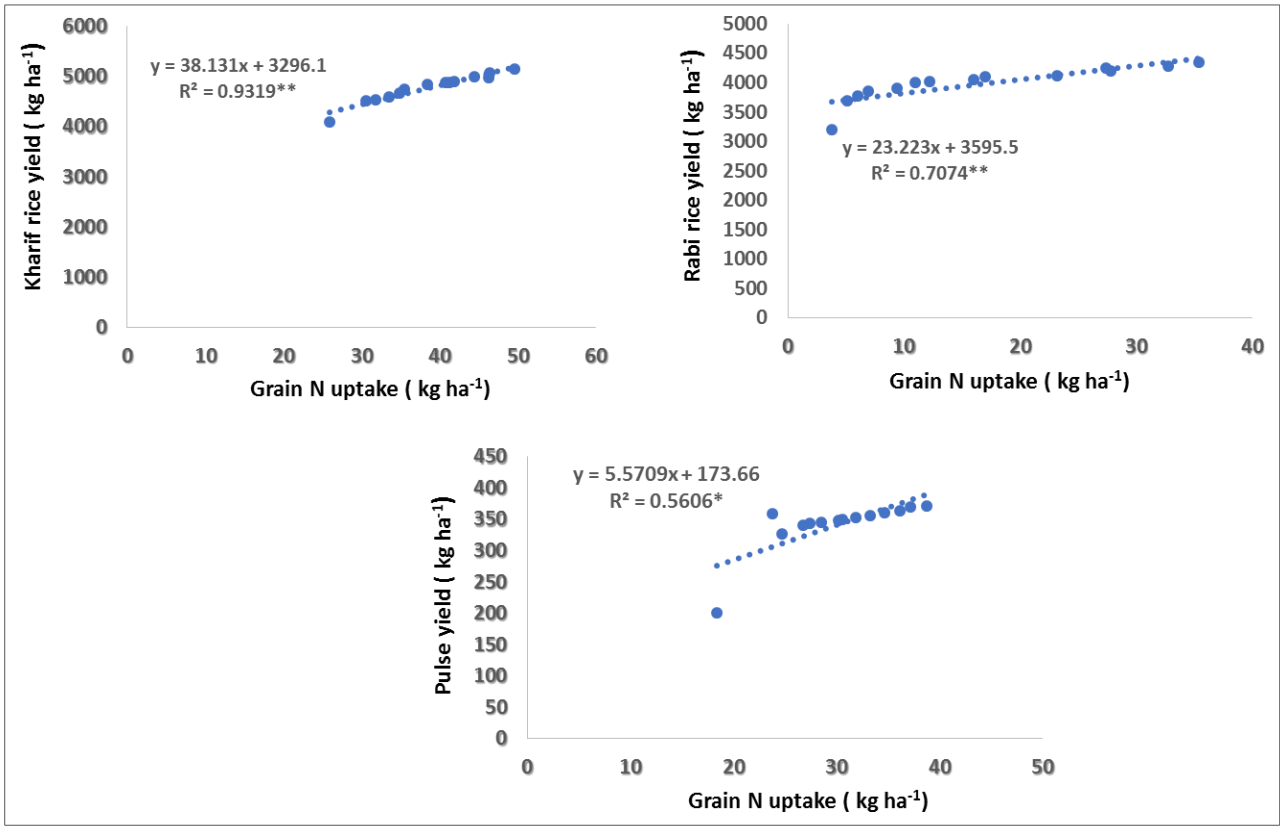


Fig 1: Linear relationship between grain yield with Grain N uptake

Residual effect (Rabi rice)

Residual effect of organics or direct effect of fertilizer N alone or both significantly increased the grain and straw yield of rabi rice over control (Table 1). Percent increase in grain yield due to residual organics alone ranged from 17.9 to 25.7 and straw yield ranged from 14.4 to 20.7. The variations noticed in rice yield among the organics may be due to differences in available form of nutrients, decomposition rate (Liza *et al.*, 2014) [21]. The pooled analysis showed, among the organics alone, the highest grain (4017 kg ha^{-1}) and straw yield (6030 kg ha^{-1}) were registered in T_6 (residual poultry manure 100% N). This may be due to higher quantity of nutrients in available form for a longer period in poultry manure than other manures (Khan *et al.*, 2007) [19]. Poultry manure was attributed to slow decomposition which probably released nutrients slowly and thus maintained higher grain yield (Hossaen *et al.*, 2011) [15]. Percent increase in the grain yield due to combined treatments ranged from 28.2 to 35.9 and straw yield ranged from 30 to 38.7.

This might be due to differences in the availability of nutrients, their nutrients fixation, their immobilization rate (Siavoshi *et al.*, 2011) [36]. The pooled data revealed that application of the residual poultry manure (50% N) + fertilizer (100%N) recorded the highest grain 4341 and straw yield 6926 kg ha^{-1} followed by residual vermicompost + fertilizer N. The highest rice yield could be ascribed to higher availability of N throughout the growth period (Audu *et al.*, 2015) [4].

The higher nutrient concentration and their uptake from the poultry manure + fertilizer N resulted in increased grain and straw yield. This was supported by positive linear relationship noticed between Grain N uptake and rabi rice yield and 70.74% of variation in grain N uptake was explained by grain yield (Fig.1)

Pulse yield

Addition of different organics and chemical fertilizer applied alone or in combination to the previous crop caused a significant increase in grain and haulm yield (Table 1) over control. The percent increase in grain yield over control due to organics ranged from 63 to 74 and in haulm ranged from 23.9 to 43.3. This could be due to increased availability of nutrients from organic manures, variations in N, P, K uptake, SOC (Sangeetha *et al.*, 2013) [37]. Application of poultry manure alone (100% N) recorded the highest grain (348 kg ha^{-1}) and haulm yield (1651 kg ha^{-1}) followed by vermicompost alone. Poultry manure increased the absorption power of soil for cations and anions particularly nitrogen which released gradually during entire growing period (Kaleeswari *et al.*, 2012) [17]. Percent increase in grain due to organics and fertilizer N ranged from 78 to 85 and haulm yield 55 to 68.6 over control. Application of residual poultry manure + fertilizer N (100 %N) recorded the highest grain (371 kg ha^{-1}) and haulm yield (1943 kg ha^{-1}) in both years. and pooled data Increase in the grain yield may be due to production of appreciable quantities of carbonic acid during decomposition of organic matter mineralize the complex organic substances which contribute the N pool and greater multiplication of microbes and mineralizes the organic bound into inorganic form (Alagappan and Venkitaswamy, 2016) [3].

Higher grain yield was attributed to higher N uptake in grain caused due to different treatments and could be described by positive linear function and 56.06% variation in grain N uptake was explained by grain yield (Fig.1)

Nitrogen uptake

Direct effect (kharif rice)

Adoption of organics or fertilizer N alone or both significantly increased nitrogen uptake over control (Table

2). Percent increase in nitrogen uptake over control due to organics alone ranged from 18.1 to 48.2 in grain and 57.5 to 91.5 in straw. The variations may be due to release pattern of nutrients, decomposition rate among the organic manures (Velmurugan and Palanivel Swarnam. 2017) [44]. Application of the vermicompost (100%N) recorded the highest nitrogen uptake 38.4 and 30.2 kg ha$^{-1)}$ in grain and straw. respectively. Increased nitrogen uptake could be ascribed to slow and continual supply of N coupled with reduced N losses which might have improved synchrony between plant N demand and supply of N in soil (Bejbaruha, *et al.,* 2009) [6]. Percent increase in the nitrogen uptake due to organics and fertilizer N ranged from 18 to 61 in grain and 60.9 to 78 in straw. Application `of vermicompost (50% N) + fertilizer N recorded the highest N uptake (49.6 kg ha^{-1}) and (48.9 kg ha^{-1}) in grain and straw respectively. The higher concentration and uptake of nutrients in vermicompost and fertilizer N amended soils might be due to readily available N coupled with rich source of the macro and micronutrients, vitamins, plant growth regulators and beneficial micro flora which made a good organic source to supply nutrients to soil in adequate manner for the plant to absorb and assimilate in their tissues (Jayakumar *et al.*, 2014) [16]. Application of vermicompost in lowland rice, the microbes gets activated and colonization of mycorrhizal fungi increased, which play an important role in mobilization of nutrients and thereby higher availability of nutrients facilitating nitrogen uptake by plants (Prasad *et al.*, 2015) [31].

Table 2: Effect of different organics and chemical fertilizer N on nitrogen uptake (kg ha^{-1}) in rice-rice- pulse #

Treatments	Direct effect (kharif)		Residual effect (rabi)*		Residual effect (rice fallow)**	
	Grain N	Straw N	Grain N	Straw N	Grain N	Haulm N
T_1-Absolute control	25.9	18.7	3.8	2.9	18.4	24.4
T_2- CCP-100%N	30.6	22.1	6.0	5.4	24.7	31.2
T_3- GM-100%N	35.5	28.2	5.1	4.8	23.8	29.9
T_4- CCT-100%N	31.8	23.6	6.9	6.4	26.8	33.9
T_5- VC-100%N	38.4	30.2	11.0	9.5	28.5	35.2
T_6- PM-100%N	34.9	27.6	12.2	11.1	30.2	37.0
T_7- FYM-100%N	33.5	25.2	9.4	9.1	27.4	33.7
T_8-CCP(50%)+ Urea(50%N)	40.8	30.1	17.0	16.8	33.3	40.1
T_9- GM(50%)+Urea(50%N)	46.3	46.3	16.0	14.7	31.9	38.3
T_{10}- CST(50%)+Urea(50%N)	41.3	34.9	23.2	18.4	34.7	41.6
T_{11}-VC(50%)+Urea(50%N)	49.6	49.9	32.8	21.8	37.2	43.9
T_{12}-PM(50%)+Urea(50%N)	46.4	45.5	35.4	26.3	38.8	45.0
T_{13}-FYM-(50%)+Urea(50%N)	41.9	40.8	27.8	22.8	36.2	42.7
T_{14}-RDF(120:38:38 kg ha^{-1}) kharif/ 150:50:50 kg ha^{-1}) Rabi	44.4	42.5	27.4	22.2	30.6	37.0
C.D @5%	2.07	0.68	0.15	0.05	0.20	0.26

Pooled data for two years * Residual effect of organics ** residual effect of organics and fertilizer N
*- Organics were applied to kharif rice and rabi rice received 100% N from T_8 to T_{14}

Residual effect (rabi rice)

Residual effect of organics or fertilizer N alone or both significantly increased the N uptake of rabi rice over control. (Table 2). Percent increase in N uptake due to residual organics alone ranged from 57.8% to 96.1% in grain and 86.2% to 98.6% in straw. The variations among the organics may be due to differences in soluble form of nutrients, mineralization rate (Moola Ram *et al.* 2014) [28]. The sole residual poultry manure (100% N) recorded the highest N uptake 12.2 and 11.1 kg ha^{-1} in grain and straw respectively. The use of the poultry manure as soil amendment would provide appreciable quantities of all nutrients which may be reason for higher N uptake in this study. Poultry manure gave the highest soil inorganic N, plant N and dry matter accumulation among the other organic manures which made superior over other (Amina Khatun *et al.,* 2016) [2]. Percent increase in N uptake over control due to organics and fertilizer N ranged from 45.2 to 98.6 in grain and 85.7 to 114 in straw, respectively. Application of residual poultry manure (50% N) + fertilizer N (100%N) recorded highest N uptake (35.4 kg ha^{-1}) and 26.3 kg ha^{-1} in grain and straw respectively by residual vermicompost + fertilizer N. This may be due to release of higher inorganic N from poultry manure which favoured the higher N uptake in rice (Tilahun *et al.,* 2013) [43]. The increase in N uptake due to poultry manure + fertilizer N could be ascribed to slow and continued supply of nutrients, coupled with reduced N losses via denitrification or leaching might have improved the synchrony between plant N demand and supply from the soil (Haile *et al.,* 2012) [13]. Poor availability and higher N losses of nutrients under RDF alone resulted lower uptake (Mohana Rao *et al.,* 2017) [25].

Pulse N uptake

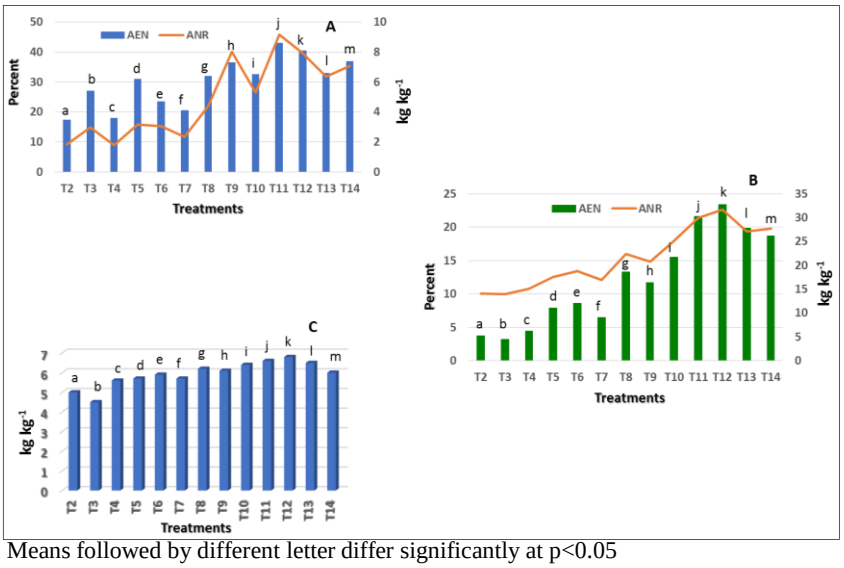
Addition of different organics and chemical fertilizer applied alone or in combination to the previous crop caused a significant increase in N uptake in grain and haulm (Table 2) over control. The percent increase in nutrient uptake due to organics in grain ranged from to 34.2 to 64.1and in haulm ranged from 27.8 to 51.6. This could be due to differences in the mineralization rate, C/N ratio, release of nutrients in available form (Masunga *et al.,* 2016) [24]. Application of residual poultry manure (100% N) recorded highest N uptake (30.2 kg ha^{-1}) in grain and (37.0 kg ha^{-1}) in haulm. The higher nitrogen content in the poultry manure resulted in higher N uptake in grain and haulm in black gram. This could be due to higher mineralization of organic nitrogen, presence of microbes which leads to transformation of nitrogen increased the N uptake in black gram (Senthilvalavan and Ravichandran 2019) [38]. Percent increase in the N uptake over control due to conjoint application of organics and fertilizer N ranged from 73.3 to 110.8 in grain and 64.3% to 84.4% in haulm over control. Application of residual poultry manure + fertilizer N recorded highest N uptake (38.8 kg ha^{-1}) in grain and 45.0 kg ha^{-1} in haulm over control. This may be due to reduction

in the bulk density which facilitates the root proliferation and its break down of the roots resulted in higher SOC which led to higher N uptake of black gram from the soil (Arif *et al.* 2014) [5]. The combinations of poultry manure and fertilizer N decreases the leaching of inorganic elements from the top soil and increased the absorption of nitrogen by the crop (Mahmood *et al.* 2017) [23]. Combined application had increased the ability to conserve the soil nutrients, eliminated the downward movement of minerals, and hence reduced leaching resulted in higher N uptake (Fabiana and Ronaldir, 2020) [11].

Nitrogen use efficiency

Direct effect (kharif rice)

Many strategies had been used to increase rice grain yield and improve crop NUE. Application of organics or fertilizer N alone or both significantly increased the nitrogen use efficiency over control (Fig.2). The variation in NUE can be understood by nitrogen doses, application methods and other agronomic factors which help to manage nitrogen has crucial effect for both profitable crop production and environment (Maragatham, 2010) [22]. Application of vermicompost (100%N) alone recorded highest response ratio (6.2 kg kg^{-1}) and apparent N recovery (15.9 %) followed by poultry manure (100%N). This may be due to narrow C: N ratio, minimum loss of nutrients and available form resulted in higher NUE over the other manures. Application of vermicompost resulted in higher mobilization of nutrients thereby better availability of nutrients facilitating higher uptake of nitrogen caused higher NUE (Cai, 2018) [7]. Application of vermicompost (50% N) + fertilizer N (50% N) recorded highest response ratio (8.6 kg kg^{-1}) and apparent N recovery (45.8%) and closely followed by poultry manure (100%N). The improvement in NUE under the combined treatments might be due to improved soil quality in terms of more C and N preservation in soil compared to sole fertilizer or organic manures (Khatun *et al.*, 2015) [18]. Zhang *et al.* (2012) [48] had presented field-experiment evidences that at a reasonable N applied, NUE was usually improved with increasing grain yield. Therefore, to further clarify the potential possibility of grain yield-NUE relationship, correlation analysis showed positive linear function and 99.94% and 88.84% variation in AEN and ANR were explained by grain yield (Fig.3a)



Means followed by different letter differ significantly at p<0.05

Fig 2: Effect of different organics and chemical fertilizer N on nitrogen use efficiency a) kharif rice b) Rabi rice c) Fallow pulse

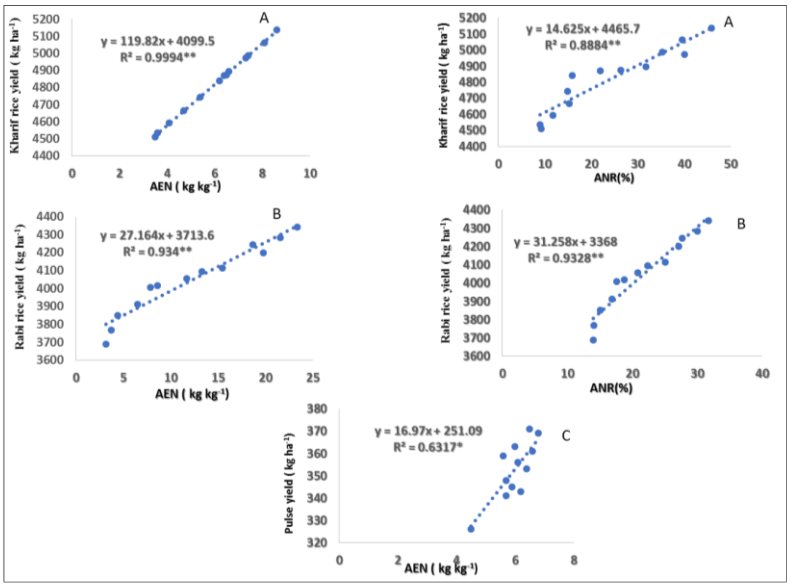


Fig 3: Linear relationship between rice and pulse yield with nitrogen use efficiency

Residual effect (Rabi rice)

Residual effect of organics or fertilizer N alone or both significantly increased the nitrogen use efficiency over control in both years and in pooled data (Table 3). The variations in the organics may be due to presence of varying quantity of nutrients, slower decomposition rate, and release pattern of nutrients (Mohammed *et al.*, 2010) [27]. Application of residual poultry manure (100%N) recorded highest response ratio (8.6 kg kg^{-1}) and apparent N recovery (18.8 %).

This may be due to minimal loss of nutrients and timely mineralization of nutrients, higher availability of nitrogen for longer period. Ramalakshmi *et al.* (2012) [32] reported that higher NUE in second year could be due to continuous supply of N and also due to residual effect. Application of residual poultry manure + fertilizer N recorded highest response ratio (23.4 kg kg^{-1}) and apparent N recovery (31.7%) and closely followed by residual vermicompost + fertilizer N. Better availability of N and reduced N losses might have increased the ANR with poultry manure while, conventional method of fertilizer application would have increased the losses and resulted in reduced recovery of N due to higher rates of ammonia volatilization and denitrification (Satheesh and Balasubramanian, 2003) [33]. Rabi rice recorded higher grain yield due to residual effect of organics and fertilizer nitrogen and this has contributed higher NUE noticed in present study and it was supported by positive linear relationship between grain yield and NUE (Fig.3b)

Residual pulse

Addition of different organics and chemical fertilizer applied alone or in combination to the previous crop caused a significant increase in NUE in pulse in two years and in pooled data (Table 3) over control. The variations may be due to variations in decomposition rate, immobilization, and solubility of nutrients (Cai, 2018) [7]. Application of residual poultry manure (100% N) recorded highest response ratio (5.9 kg kg^{-1}). This may be due to higher availability of N and reduced N losses, higher mineralization rate (Nishida, 2011). Application of residual poultry manure + fertilizer N recorded highest response ratio (6.8 kg kg^{-1}) closely followed by residual vermicompost. The combined application of poultry manure + fertilizer N resulted in increased N accumulation, faster release of inorganic nitrogen thereby resulted in higher NUE in rice (Cheng Hu, 2019). In rice fallow pulse, 63.17 % variation in AEN was explained through grain yield as noticed in regression equation (Fig. 3c)

Conclusion

Rice cropping sequence responded significantly to the organics or fertilizer N alone or both in clay loam soil. Based on the experimental results, application of either vermicompost or poultry manure@ (50% N) + fertilizer N (50%N) gave higher yield, nitrogen uptake and nitrogen use efficiency in rice-rice-pulse cropping system.

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