Plant Archives Vol. 20, Supplement 1, 2020 pp. 2644-2649 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

POST HARVEST SOIL FERTILITY STATUS OF RICE-BLACK GRAM CROPPING SYSTEM IN *TYPIC HAPLUSTERTS* INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT AND CROP CULTIVATION TECHNIQUES

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Abstract

Studies on the consequences of integrated nutrient management (INM) on post harvest soil fertility status of rice-black gram grown in Vertisol (*Typic Haplusterts*) were conducted at experimental farm, Annamalai University, a tail end of Cauvery Deltaic Zone (CDZ) of Tamil Nadu. Late Samba rice was grown with 12 treatments (inorganic alone, inorganic plus organic sources) under two crop establishment methods (system of rice intensification (SRI) and conventional system of cultivation (CSC), whereas black gram was grown as residual crop in 2014 and 2015. Soil physico-chemical properties, microbial population and soil available macro and micro nutrient contents in post harvest soil of the experiments were significantly influenced by INM practices, especially when soil test crop response (STCR) based integrated plant nutrient supply (IPNS) practice to rice. There was not much change in the soil pH and EC. However, a distinct increase (10 - 14 per cent) was noticed in over all post harvest soil fertility status in INM treatments compared to non INM treatments in crops both under SRI and CSC.

***Keywords*:** Black gram, EC, IPNS, pH, Rice, Residual crop, Soil fertility, SRI, STCR

Introduction

Rice is the major cereal crop of Cauvery Deltaic Zone (CDZ) of Tamil Nadu and occupies an area of 1.45 million hectares which is equivalent to 11.13 percent of the state area with an average production of 3.42 t ha^{-1}. The production of rice alone is not sufficient to meet farmers' economic needs in Cauvery Deltaic Zone of Tamil Nadu. Hence, rice fallow pulse is grown residual crop without any extra input except some agronomic practices like weeding and life irrigation rarely. Which generate much more income to the farmers to meet the economic needs during off season /failure monsoon with zero water and nutrient inputs is possible. Among the rice based cropping system, rice –pulse is one of the most prevalent and important cropping system in CDZ, more so in the coastal CDZ. With the advantage of considerable area under rice fallow pulse system and retreating monsoon, pulse crop of black gram fits into the system and is preferred by the farmers of CDZ as second crop(residual) after rice. Since, there is question of soil fertility status after growing particular cropping sequence like rice-pulse to maintain the soil health. In addition, nutrient imbalance due to continuous use inorganic alone or combined with sub-optimal rates of nutrients has been the cause of non-sustainable rice fallow pulse production in this zone. Further, farmers of this zone do not pay any scientific attention towards maintaining the soil health to keep the soil fertile and it almost negligible even if the nutrients are in deficient in soil and they follows general or blanket application of nutrient sources without knowing the real picture it. This ignorance and off-centered application of nutrient sources accompanied with restricted use of organics have made soils not only deficient in nutrients, but also deteriorate soil health, resulting in decline of crop response to the recommended fertilizer doses and positive residual effects on maintain soil fertility. Where growing fallow pulse crops after main cereals generate more multi-nutrient deficiency in soils especially rice based cropping system. Declining trend in productivity has observed in many long-term experiments throughout the Indian state of these crops. Under these circumstances, it is necessary to integrating organic and inorganic nutrient sources with scientific approach to bring prospective results in rice based cropping systems along with sustained productivity plus soil health. Hence, present investigation of involving various INM practices under SRI and conventional system rice cultivation was taken up in rice –black gram cropping system to overcome the declining trend of soil fertility status.

Materials and Methods

Field experiments were conducted for two consecutive years in late samba season during 2014 and 2015 at Experimental Farm, Annamalai University, Annamalai Nagar Tamil Nadu, India. Soil of the experimental farm is classified as Typic Haplusterts (clay) having holding capacity of 36.5 and 36.7 per cent, neutral in reaction (pH 7.4,7.5) organic carbon content 4.6 and 5.8 g kg^{-1}, CEC of 20.7 and 21.4 c mol (P+) kg $^{-1}$, low available N (227 and 230 kg ha^{-1}), medium available P (1.9and 21.3 kg ha^{-1}), high available K (281 and 276 kg ha^{-1}); DTPA extractable Fe, Zn, Mn and Cu soil content of 21.2,2.1,3.7,1.1 and 20.8,2.7,3.7,0.9 mg kg^{-1}, respectively at first and second year experimental soils. Experiment was laid in split plot design with two methods of cultivation (SRI and CSC) as main plot treatments and twelve sub plot treatments viz., three inorganic alone applied treatments (100 % RDF, STCR based RDF, LCC based N (Recommended dose of fertilizer P&K without basal N), nine integrated nutrient management treatments (STCR based IPNS, based on 100 % RDF two levels of fertilizer nitrogen (75and 50 per cent) in combination with two levels of N (25 and 50 per cent) through different organic manures viz., Farmyard manure (FYM), Green manure (GM), Press mud (PM), Poultry manure (POM) as sub plot treatments, and replicated thrice. The rice variety CO-43 and black gram ADT-3 (crops matures normally in 135 days and 75 days, respectively) used as test crops. The total nutrients were supplied through organic sources inorganic fertilizers were given at the rate of 150-50-50 kg N, P, and K ha^{-1}, and 8 kg

Zn ha^{-1} through urea, single super phosphate, muriate of potash, and zinc sulfate, respectively. Nitrogen was given in three equal splits at basal, maximum tillering, and panicle initiation stages, while P, K, and Zn were given as basal doses. For SRI-organic treatments, the N dose was adjusted to the recommended level based on the moisture content and total N concentration of the organic sources. Soil samples were collected after harvest of crop (post harvest soil samples) and analyzed for physico-chemical properties, microbial population and available macro and micronutrients using standard analytical procedures. All the data were statistically analyzed and the significance of the difference between the means of the treatments, least significant difference (LSD) was calculated at the 5 % probability level.

Results and Discussion

Post harvest soil fertility status:

Soil physico-chemical properties

Present investigation results showed better improvement in soil physical properties observed viz., bulk density, per cent pore space except particle density (it is an inherent factor of parent materials naturally occurred in pedogenic processes). Continuous supply of nutrients to plants based on individual crop requirement through fertilizer alone would deteriorate soil fertility. In this study, fertilizers combined with organics were tested on physico-chemical properties of post-harvest soils of rice and its fallow pulse (black gram) grown for two years. The soil pH and EC of the post harvest soils of rice – black gram varied within a narrow range among the treatments and the differences were not statistically significant. The organic carbon (OC) content increased significantly from initial values of 4.6 and 5.8 g kg^{-1} and attained a maximum of 7.8 g kg^{-1} after the second year of experiment, which was recorded in T_4 (STCR based IPNS to rice and residual effect to fallow black gram) (Table 1). Whereas, physical properties i.e. bulk density and pore space were influenced significantly (table 2). Bulk density values were concisely maintained under SRI (1.30 Mg m^{-3}) compared to conventional system (1.25 Mg m^{-3}), respectively. Among treatments, bulk density values ranged from 1.25 to 1.32 and 1.23 to 1.30 Mg m^{-3}. Even though all treatments were statistically significant from one another, they were not in length of altering the bulk density and interaction effects on bulk density were found to be non significant in both years. The agronomic principles used in SRI were not altering the physical properties of soil directly but indirectly through active soil aeration (vigorous root development) and more facilitated rhizosphere conditions attributable to reduce bulk density and balanced pore space per cent. Aggregate stability is a bedrock thing in questions of soil physical fertility and can be enhanced by means of an appropriate management of organic amendments, which can maintain appropriate soil structure. These agronomic procedures might have improved the pore space suitable for gas exchange, water retention, root growth and microbial activity (Van-Camp *et al.,* 2004). After harvest, root biomass below ground undergoes decomposition which in turn make soil become rich in organic matter are less prone to erosion processes than soils with low content of root biomass. The organic matter stabilizes soil structure by at least two different mechanisms: by increasing the inter-particle cohesion within aggregates and by enhancing their hydrophobicity, thus decreasing their breakdown. In particular, increase in soil microbial activity, especially due to addition of organic manures, could be responsible for increase in soil structural stability. According to Abiven *et al.* (2008), several biological binding agents have been recognized as accountable for aggregation and aggregate stability. Polysaccharides synthesized by microorganisms, particularly at the beginning of organic matter decomposition, tend to adsorb mineral particles and increase their inter-cohesion. Conversely, products rich in humic compounds (organic manures) would also be expected to increase aggregate hydrophobicity of clays. Decreases in soil bulk density, on average of 15 %, after long-term compost, farmyard manure or digested sewage sludge agricultural use, suggesting that addition of composted and fresh organic matter facilitated, as a consequence, soil porosity connected to soil bulk density (Meng *et al*., 2005; Chaudhari *et al*., 2013; Kharche *et al*., 2013). Present study results are in conformity with those of Sarkar *et al*., 2018.

Particle density of the experimental field ranged from 2.61 to 2.62 Mg m^{-3} and it was unaltered by cultivation methods and nutrient management options in both years. Pore space was concisely increased in SRI (51.42 per cent) over conventional system (50.26 per cent) but increased from the initial soil test values of 49.5 and 48.8 per cent. Among treatments, pore space per cent values ranged from 49.85 to 52.34 and 49.83 to 52.32 per cent. The values increased around 4.7 to 4.8 per cent and interaction effects found to be non significant in both years. Porosity is a measure of the size and system of voids in the soil matrix which affect both aeration and water movement. In addition, Singh *et al.* (2002) reported that incorporation of organic amendments (FYM) reduced the bulk density of soil. On contrary, Eghball (2002) reported that soil bulk density was unaltered by 4-year manure or compost application. The above said research reports proved and are in conformity with the present study results that post harvest soil physical properties improved considerably under rice fallow pulse cropping system. Further, in the present investigation, residual effect of STCR based IPNS (combined application of fertilizer along with 12.5 t ha^{-1} FYM and bio-fertilizers *viz*., *Azospirillum* and *PSB* as soil treatment) had resulted in greater improvement in soil physical properties and it was followed by other INM substituted plots. It might be due to readily decomposable huge addition of organic matter from both rice and blackgram debris, had an advantage of releasing various humic fractions thus involved in aggregation of soil particles, apart from that blackgram exerted their root system deep into lower horizons of soil, helped in binding soil particles together extensively led to improvement of physical properties as observed by Prakash *et al.* (2008), Tejada *et al.* (2008; 2009) and Srilatha *et al.*, 2013.

Soil microbial population

Microbial population (Bacteria x 10^{6} CFU g^{-1}, fungi x 10^{3} CFU g^{-1}, actinomycetes x 10^{4} CFU g^{-1}) counted for two years (table 3), where under SRI plots were found to be superior by registering higher microbial population (50.61, 13.64, 9.98) and lower microbial population was noticed with conventional method (44.51, 11.18, 7.89). this could be ascribed duly by microbes harboring rhizosphere of crops provide benefits to crops through better nutrient availability by way of atmospheric N_2 fixation or solubilizing insoluble forms of nutrients (Pandey *et al*., 2010) and play a key role in organic matter decomposition, nutrient cycling and other chemical transformations in soil (Murphy *et al*., 2007) which proved higher microbial population. Comparatively microbial population *viz*., bacteria, fungi, actinomycetes, increased as the crop growth advanced compared to initial level under SRI plots could be attributed to larger root volume along with favorable soil condition. This is in corroboration with the findings of Randriamiharisoa *et al*. (2006) and Kumar *et al*. (2007) who opined that larger canopies and root systems of SRI plants release more carbohydrates and amino acids into the soil as root exudates, enriching the rhizosphere and supporting greater microbial biomass and diversity. Similar results were observed by Zhao *et al*. (2010).

Among nutrient sources applied the residual effect f STCR based IPNS (T_4) found to be superior by registering higher microbial population of 68.6, 18.16, 13.17 and it was followed by T_5>T_6>T_8>T_7>T_9, T_{10}, T_{12}, T_{11}>$T_2$and T_1. Maximum number of microbial colonies formed under SRI in treatment received STCR based IPNS (71.71, 18.02, 12.71 and 72.94, 9.25, 13.94) and minimum population recorded in T_3 under conventional method. Maximum population of soil bacteria, fungi and actinomycetes in the post harvest soil of rice fallow black gram might be attributable to higher organic carbon content attributed by addition of inorganic and organic manures and external application of bio-fertilizers to the preceding crop and effective below ground activities of leguminous black gram. These records are in line with the reports of Kalaiyarasi (2009) and Shwetha *et al.* (2011). Further, Marschner *et al*. (2003) reported that organic and inorganic fertilizers affect the population, composition and function of soil micro organisms and inorganic fertilizers had relatively less effect on soil microbial biomass and activities than organic fertilizers. Balanced fertilization of N, P and K had a higher microbial biomass than P and N deficiency fertilizations. Chu *et al*. (2007) and Zhao *et al*. (2010) reported similar results that close relations between microorganism growth and activity to organic matter content in soil as this provided carbon and energy sources for the growth of microorganisms. Lower microbial population was observed under treatment LCC based N application (T_3) 32.44, 9.40, 6.99, respectively might be due to use of only chemical fertilizers in the rice based cropping system resulted in poor soil microbial index and crop index. Interaction effects between cultivation methods and nutrient management practices were significant.

Table 1 : Post harvest soil physico-chemical properties of rice-black gram cropping system (mean of 2 years)

Treatments	Bulk density ($Mg\ m^{-3}$)			Particle density ($Mg\ m^{-3}$)			Per cent pore space		
	SRI		CSC	SRI		CSC	SRI		CSC
T_1 -100% RDF	1.31		1.27	2.60		2.60	50.6		49.2
T_2 - STCR Based RDF	1.30		1.26	2.60		2.60	51.1		49.7
T_3 - LCC Based N (RDF P&K)	1.25		1.21	2.59		2.60	50.6		49.1
T_4 - STCR Based IPNS	1.31		1.28	2.60		2.60	53.1		51.6
T_5 -75% fertilizer N +25% organic N (FYM)	1.30		1.26	2.60		2.59	53.0		51.5
T_6 -75% fertilizer N +25% organic N (GM)	1.30		1.26	2.60		2.59	53.0		51.5
T_7 -75% fertilizer N + 25% organic N (PM)	1.29		1.25	2.60		2.60	52.3		50.8
T_8 -75% fertilizer N + 25% organic N (POM)	1.29		1.25	2.59		2.59	51.6		50.1
T_9 -50% fertilizer N + 50% organic N (FYM)	1.25		1.21	2.60		2.59	50.9		49.6
T_{10} -50% fertilizer N + 50% organic N (GM)	1.25		1.21	2.59		2.60	51.5		50.0
T_{11} -50% fertilizer N + 50% organic N (PM)	1.27		1.23	2.60		2.59	50.9		49.6
T_{12} -50% fertilizer N + 50% organic N (POM)	1.28		1.24	2.59		2.59	51.9		50.4
	M	**S**	**M x S**	**M**	**S**	**M x S**	**M**	**S**	**M xS**
SEd±	0.003	0.002	0.004	0.002	0.003	0.004	0.108	0.068	0.142
CD (P=0.05)	0.014	0.005	NS	NS	NS	NS	0.465	0.141	NS

Table 2 : Post harvest soil microbial population of rice-black gram cropping system (mean of 2 years)

Treatments	Bacteria x 10^6 CFU g^{-1} (dry soil)			Fungi x 10^3 CFU g^{-1} (dry soil)			Actinomycetes x 10^4 CFU g^{-1} (dry soil)		
	SRI		CSC	SRI		CSC	SRI		CSC
T_1 -100% RDF	43.1		39.2	11.7		10.8	8.65		7.97
T_2 - STCR Based RDF	43.3		39.4	11.8		10.8	8.68		8.00
T_3 - LCC Based N (RDF P&K)	35.0		32.4	9.72		9.07	7.22		6.76
T_4 - STCR Based IPNS	72.9		64.3	19.3		17.1	13.9		12.4
T_5 -75% fertilizer N +25% organic N (FYM)	62.9		56.0	16.7		15.0	12.2		10.9
T_6 -75% fertilizer N +25% organic N (GM)	58.0		51.7	15.5		13.9	11.3		10.2
T_7 -75% fertilizer N + 25% organic N (PM)	52.2		47.5	14.0		12.8	10.3		9.42
T_8 -75% fertilizer N + 25% organic N (POM)	55.1		50.2	14.8		13.5	10.8		9.90
T_9 -50% fertilizer N + 50% organic N (FYM)	48.0		43.7	13.0		11.9	9.51		8.75
T_{10} -50% fertilizer N + 50% organic N (GM)	47.1		42.9	12.8		11.7	9.35		8.61
T_{11} -50% fertilizer N + 50% organic N (PM)	44.3		40.3	12.1		11.1	8.86		8.16
T_{12} -50% fertilizer N + 50% organic N (POM)	45.5		41.5	12.4		11.3	9.08		8.36
	M	**S**	**M x S**	**M**	**S**	**M x S**	**M**	**S**	**M xS**
SEd±	0.37	0.72	1.04	0.12	0.20	0.28	0.09	0.15	0.21
CD (P=0.05)	1.59	1.45	2.40	0.50	0.41	0.66	0.39	0.31	0.48

Soil available nutrients (N, P, K (kg ha^{-1}) and Fe, Mn, Zn, Cu (mg kg^{-1})

Enduring effect of cultivation methods and nutrient management practices applied to rice was significant in improving available macro (NPK) and micro (Fe, Mn, Zn, Cu) nutrient status in soil after the harvest of black gram in both years (table 4) this might bring an idea how the nutrient availability enhanced in the production system. Significantly, higher availability of N, P, K were observed with SRI (233.9, 20.8, 290.5 kg ha^{-1}) compared to conventional system (211.1, 18.8, 276.5 ka ha^{-1}). The total chemical fertility status of main plots (SRI and CSC) after the harvest of rice fallow black gram varied significantly. This could have been ascribed due to SRI cultivation system maintained higher levels of the said nutrients at the end of rice crop as compared to conventionally maintained plot for rice. These results are in line with those of Sureshkumar *et al.*2016.

Among nutrient sources and levels tried (inorganic alone, combined application of inorganic and organics) soil available NPK was higher with integrated nutrient management treatments than inorganic fertilizer N alone applied plots to the preceding rice crop, after harvest of rice fallow black gram. Inclusion of legumes in cereal cropping rotations could theoretically increase soil N concentration and at least, control the decline of soil N fertility associated with the cropping system as reported by Ahmad *et al.* (2001). Soil available N was maximum in T_4 (251 kg ha^{-1}) and on par with T_5, followed by T_6, $T_8 > T_7 > T_{10}$, T_9, T_{11}, $T_{12} > T_2$ and T_1. Treatment received LCC based N application T_3 recorded minimum available N (172.7 kg ha^{-1}). With respect phosphorus, higher soil available P was observed by T_4 (22.2 kg ha^{-1}) followed T_5, T_6, T_8, T_7, T_9, T_{10}, T_{11} $T_{12} > T_2$ and T_1. Lower value of available P was registered by T_3 (13.7 kg ha^{-1}). Whereas the soil available K registered higher value in T_4 as in N and P but the trend of K availability differed in each treatment.T_4 (297.2 kg ha^{-1}) was on par with T_6, T_5 and T_7 followed by T_8, T_{12}, T_{11}, T_2, T_1, T_{10} and T_9 and lower available K was witnessed in T_3 (247.5 kg ha^{-1}).

The highest N, P and K status of post harvest soil could be attributed due to residual effect of STCR based IPNS (combined application of fertilizer along with 12.5 t ha^{-1} FYM and bio-fertilizers *viz*., *Azospirillum* and *PSB* as soil treatment).The beneficial effect of FYM could be attributed to release of available nutrients by decomposition of added manure and also mineralization of unavailable forms through increased activity of microorganisms led to greater availability of applied and inherent nutrients. This might have indirectly contributed to higher soil nutrient status along with nitrogen fixation by legumes which led to higher post harvest soil available nutrients at the end of the rice fallow pulse crop. The present findings are supported by the results of Britto and Girija (2006). Further, addition of higher quantity of organic matter through black gram litter fall, roots and root nodules produced organic acids which in turn stabilized native nutrients and led to availability of major nutrients for longer period. Similar findings were also documented by Barik *et al.* (2006).

From the results, it appears that available micronutrients status (DTPA extractable Fe, Mn, Zn, Cu) were influenced by cultivation methods and nutrient management practices (table 4). In both years Fe, Mn, Zn, Cu availability were higher under SRI (16.19, 2.69, 1.07, 1.41 mg kg^{-1}) than CSC (13.41, 2.42, 0.96, 1.27 mg kg^{-1}). Among treatments,T_4 registered higher values of Fe, Mn, Zn, Cu (19.68, 3.31, 1.34, 1.76 mg kg^{-1}) followed by T_5, T_6, T_8 ; T_7, T_{10}, T_9 ; T_{11}, T_{12},T_2 and T_1.While LCC based N applied treatment recorded lower values (8.05, 1.55, 0.59, 0.78 mg kg^{-1}) compared to all other treatments and interaction effects were found to be non significant. The same trend was followed by Fe, Mn, Zn and Cu availability as macronutrients in the study.This might be due to the synergistic and collective carry over effect of the conjoint use of organic and inorganic nutrients to rice crop. These results are line with the findings of Ramesh (2008) and Ramesh *et al*. (2009). Further, a plenty of studies, concerning long-term fertility trials, pointed out that soil organic material applications increased organic carbon stock and, therefore, increased cation exchange capacity this might be due to high negative charge of organic matter and it is important for retaining nutrients and making them available to plants (García-Gil *et al*., 2004; Ros *et al*., 2006; Weber *et al*., 2007; Kaur *et al*., 2008). On contrary, the lower values of soil available nutrients were observed under the plots treated with inorganic fertilizers alone.

Table 3 : Post harvest soil available macro nutrient (NPK) contents of rice-black gram cropping system (mean of 2 years)

Treatments	N kg ha^{-1}			P kg ha^{-1}			K kg ha^{-1}		
	SRI	CSC		SRI	CSC		SRI	CSC	
T_1 -100% RDF	206.9	188.1		17.0	15.4		281.6	268.0	
T_2 - STCR Based RDF	208.1	189.1		17.1	15.5		284.0	269.2	
T_3 - LCC Based N (RDF P&K)	174.7	159.8		13.9	12.7		246.7	232.7	
T_4 - STCR Based IPNS	257.6	228.6		22.8	20.2		294.4	281.4	
T_5 -75% fertilizer N +25% organic N (FYM)	254.2	225.6		22.6	20.0		291.0	277.8	
T_6 -75% fertilizer N +25% organic N (GM)	246.0	218.5		22.1	19.6		290.1	279.6	
T_7 -75% fertilizer N + 25% organic N (PM)	232.9	210.4		21.3	19.3		289.7	278.2	
T_8 -75% fertilizer N + 25% organic N (POM)	240.9	217.5		21.8	19.6		283.8	269.5	
T_9 -50% fertilizer N + 50% organic N (FYM)	228.1	207.4		21.1	19.2		271.7	261.2	
T_{10} -50% fertilizer N + 50% organic N (GM)	230.3	209.4		21.1	19.2		273.4	262.8	
T_{11} -50% fertilizer N + 50% organic N (PM)	220.3	200.3		20.7	18.8		285.3	266.1	
T_{12} -50% fertilizer N + 50% organic N (POM)	219.2	199.3		20.6	18.7		285.4	267.4	
	M	**S**	**M x S**	**M**	**S**	**M x S**	**M**	**S**	**M x S**
SEd±	3.45	3.31	5.65	0.31	0.39	0.62	2.12	2.01	3.45
CD (P=0.05)	14.84	6.66	NS	1.32	0.80	NS	9.13	4.05	NS

Table 4 : Post harvest soil on available micro nutrient (NPK) contents of rice-black gram cropping system (mean of 2 years)

Treatments	Fe mg kg^{-1}			Mn mg kg^{-1}			Zn mg kg^{-1}			Cu mg kg^{-1}		
	SRI	CSC		SRI	CSC		SRI	CSC		SRI	CSC	
T$_1$ -100% RDF	14.03	11.62		14.33	11.89		8.86	7.24		21.74	17.62	
T$_2$ - STCR Based RDF	20.51	16.81		19.57	16.01		17.01	14.31		17.51	14.76	
T$_3$ - LCC Based N (RDF P&K)	16.02	13.41		15.63	13.06		14.43	11.98		14.64	12.16	
T$_4$ - STCR Based IPNS	2.24	2.03		2.25	2.05		1.61	1.48		3.52	3.10	
T$_5$ -75% fertilizer N +25% organic N (FYM)	3.39	3.01		3.17	2.81		2.82	2.56		2.84	2.57	
T$_6$ -75% fertilizer N +25% organic N (GM)	2.73	2.48		2.77	2.52		2.43	2.21		2.50	2.27	
T$_7$ -75% fertilizer N + 25% organic N (PM)	0.87	0.79		0.88	0.80		0.62	0.57		1.42	1.25	
T$_8$ -75% fertilizer N + 25% organic N (POM)	1.35	1.20		1.26	1.12		1.10	1.00		1.11	1.01	
T$_9$ -50% fertilizer N + 50% organic N (FYM)	1.18	1.08		1.08	0.98		0.95	0.86		0.98	0.89	
T$_{10}$ -50% fertilizer N + 50% organic N (GM)	1.15	1.05		1.16	1.05		0.81	0.75		1.87	1.65	
T$_{11}$ -50% fertilizer N + 50% organic N (PM)	1.79	1.58		1.66	1.48		1.45	1.32		1.46	1.33	
T$_{12}$ -50% fertilizer N + 50% organic N (POM)	1.56	1.42		1.43	1.30		1.25	1.14		1.29	1.17	
	M	**S**	**M x S**	**M**	**S**	**M x S**	**M**	**S**	**M x S**	**M**	**S**	**Mx S**
SEd±	0.43	0.49	0.79	0.02	0.05	0.07	0.01	0.02	0.03	0.02	0.04	0.06
CD (P=0.05)	1.87	0.99	NS	0.10	0.10	NS	0.04	0.04	NS	0.09	0.09	NS

Conclusions

From the present the present investigation, it may concluded that soil physico-chemical properties, microbial population and soil available macro and micro nutrient contents in post harvest soil were significantly influenced by INM practices, especially when soil test crop response (STCR) based integrated plant nutrient supply (IPNS) practice to rice both under SRI and CSC in rice –black gram cropping sequence.

Acknowledgment

The authors are thankful to Faculty of Agriculture, Annamalai University, Tamilnadu, India for providing research farm and laboratory support for carrying out the present study .

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