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INFLUENCE OF ESTABLISHMENT METHODS AND INTEGRATED NITROGEN MANAGEMENT ON GROWTH, PRODUCTIVITY AND SOIL FERTILITY OF RICE (*ORYZA SATIVA* L.)

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ABSTRACT
A field experiment was conducted at GBPUA and T, Pantnagar, Uttarakhand, for two years (2010 to 2011) during *Kharif* to study the effect of varying nitrogen sources and methods of rice establishment, yield attributes, productivity, economics of rice (*Oryza sativa*) and soil fertility status. The treatment comprised of three rice establishment methods *viz.*, conventional transplanting(CT), system of rice intensification(SRI) and aerobic rice (DSR) in main plots and four nutrient sources *viz.*,$N_{25(FYM)}$ + $N_{95(urea)}$, $N_{50(FYM)}$ + $N_{70(urea)}$, $N_{75(FYM)}$ + $N_{45(urea)}$ and $N_{120 (urea)}$ in sub-plots tested in split plot design with four replications. Significantly higher number of filled grains per m^2, panicle weight, test weight and grain yield were achieved due to SRI compared to conventional transplanting and aerobic rice cultivation. System of rice intensification recorded significantly higher grain yield (5.49 t/ha, averaged over two years) being 11% higher than conventional transplanting. Lowest grain yield (4.63 t/ha, averaged over two years) was recorded under aerobic rice being 7% lower than conventional transplanting. Among the nutrient sources, $N_{75 (FYM)}$ + $N_{45 (urea)}$ significantly enhanced the number of panicles per m^2, panicle length, panicle weight, number of filled spikelets per panicle, filled spikelets per m^2,1000-grain weight and yield of rice (5.17t/ha, averaged over two years) compared to nitrogen through urea alone.

INTRODUCTION

Rice is the staple food for about 50 per cent of the world's population that resides in Asia, where 90 per cent of the world's rice is grown and consumed. In India, it is estimated that the demand, of rice will be 140 million tons in 2025. At present, India has 42.41 million hectare of land under rice cultivation with a production of 105.24 million tons (DAC, Govt. Of India, 2012-13,). To assure food security in the rice consuming countries 50 per cent increase in the rice production is required by 2025. This additional rice will have to be produced on less land with less usage of water, labour and chemicals (Zheng *et al.*, 2004). Therefore, the productivity of rice has to be increased through adoption of suitable and newer technologies. In future, we have to increase food production with less water by adopting techniques of higher water use efficiency. Increasing water scarcity, now forcing farmers towards less water demanding technologies even sacrificing some yields of crop. Aerobic rice cultivation, where fields remain unsaturated throughout the season like an upland crop offers an opportunity to produce rice with less water (Bouman *et al.*, 2002)

The conventional transplanting method of rice cultivation is the most widely adopted method of rice production which require high continuous water inputs and labour, usually at a critical time for labour availability, which often results in shortage and increasing labour costs that not only increases the cost of production but high water requirements also threatens the sustainability of the irrigated rice system and food security in Asia (Tuong and Bouman, 2003).

The System of Rice Intensification (SRI), developed over a 20 year offers opportunities to researchers and farmers to expand their understanding of potentials already existing in the rice genome. The SRI is a new methodology for increasing the productivity of irrigated rice by changing the management of plants, soil, water and nutrients resulting in both healthy soil and plants, supported by greater root growth and the soil microbial abundance and diversity. The SRI was recently introduced into India and slowly gaining momentum since 2003. If SRI were to be applied with the water now being used for rice irrigation, it would be able to increase irrigated area by at least 50 %, leading to 50 % increase in rice production (Thakkar, 2005)

Rice cultivation under non-flooded conditions (aerobic) is an alternative to the conventional rice cultivation system in regions where rainfall and fresh water resources are limited. Aerobic rice cultivation is becoming popular as it reduces the amount of irrigation water for rice while realizing high yields and increasing water productivity (De Dutta, 1996). Input water savings of 35-57% have been reported for dry seeded rice sown into non pudd led soil with the soil kept near saturation or field capacity compared with continuously flooded (5 cm) transplanted rice (Singh *et al.*, 2003).

Among the plant nutrients, nitrogen deficiency is one of the major limiting factors for cereals. Hence, fertilizer nitrogen application is an essential input for crop productivity preferentially rice. In estimation it was found that 24 % of the increase in Asian rice was attributed to use of fertilizers, mainly nitrogen. It has been observed that the rice crop needs a higher amount of N (greater than 120 kg N / ha) to achieve a good yield. However, it is subjected to huge losses as its efficiency in rice is less than 40 % of the applied N. These losses could be minimized greatly by substituting chemical fertilizer with organic manure in an integrated manner. After realizing the fact an investigation was undertaken to study the effect of rice establishment methods and integrated nitrogen sources on growth, yield of rice and soil fertility.

MATERIALS AND METHODS

Field experiments were carried out at A-2 block of N.E Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, District U.S. Nagar, Uttarakhand, India during 2010-11 and 2011-12. It is situated at 29ºN latitude, 79.29ºE longitude and at an altitude of 243.94 meters above mean sea level. In a narrow east-west belt (8-25 km wide) under the foot hills of Shivalik range of Himalayas known as *tarai*. The experimental soil is of alluvial in origin, relatively young and is classed as Aquic Hapludoll. The chemical analysis of top 15 cm soil showed that it was rich in organic matter and medium in phosphorus and potassium, and neutral to slightly alkaline in reaction. The experimental field has been under rice-wheat rotation since 1966. An exhaust crop of wheat has been grown during *rabi* season before experimental crop of rice every year on fixed site for two years.

The experiment consisted of twelve treatment combinations with three rice establishment methods *viz.,* Conventional Transplanting (CT), System of Rice Intensification (SRI) and Direct seeded Aerobic rice (DSR) in main plots, and four nutrient resources *i.e.* N_{25} (through FYM) + N_{95} (through Urea), N_{50} (through FYM) + N_{70} (through Urea), N_{75} (through FYM) + N_{45} (through Urea) and N_{120} (through Urea) in sub plots replicated four times was laid out in split plot design (SPD) in 8m^2 plots during both the years. The variety used for experimentation was "Pant Dhan18" which is of medium duration (125-130 days) semi-dwarf, stiff-stemmed, good tillering and high yielding (62-65q/ha) variety. The certified seeds were used at the rate of 5 kg/ha for SRI, 35kg /ha for conventional transplanting and 50 kg /ha for aerobic rice. The rice seedlings were raised on a raised bed size of 1.25 m x 8m x0.15m (height) with wet-bed method. The chemical analysis of FYM showed 0.50% N, 0.13% P and 0.36% K in 2010, whereas, 0.50%N, 0.14%P and 0.40% K in 2011. Nitrogen was supplied through N containing fertilizers (urea and FYM) as per treatments. Phosphorus and potassium were supplied through single super phosphate (SSP) and muriate of potash (MOP), respectively. In both years, before transplanting and sowing of rice, the FYM was applied @5t/ha (dry weight basis) in N_{25} (FYM) +N_{95} (urea), 10 t/ha in N_{50} (FYM) + N_{70} (urea) and 15t FYM / ha in N_{75} (FYM) + N_{45} (urea). It was thoroughly incorporated into the top 15 cm soil with the help of spade. Five random plants were sampled from each plot for growth and yield attributes.The area of leaves of five plants was measured with the help of leaf area meter (Model 3100, USA) and Leaf Area Index (LAI) was calculated by using the following formula: LAI= Total leaf area per plant (cm^2) ÷Ground area occupied per plant (cm^2). The soil samples were analyzed for soil reaction (pH) and electrical conductivity using 1:2.5 soil water ratio. Organic carbon was determined using Walkley and Black's rapid titration procedure (Walkley and Black, 1934). Alkaline permanganate method was followed for estimation of available N (Subbiah and Asija, 1956). Available P content was determined spectrophotometrically following the procedureof Olsen using NaHCO3 (pH 8.5) as extractant. Available K 25 mL Ammonium acetate was added in 5gm soil and contents were shaken for 5min. The filtrate was used for estimation of available K (Hanway and Heidle, 1952).

RESULTS AND DISCUSSION

Growth attributes

Plant height at harvest was significantly higher in both the years as compared to conventional transplanting (CT) and aerobic (Table 1). This can be attributed to more space, sunlight and nutrient available in SRI due to wider spacing (Thakur *et al.*, 2010).). Among INM treatments, N_{75}FYM + 45N (Urea) recorded significantly higher plant height as compared to rest of combination. This might be due to continuous supply nitrogen for longer duration. Significantly higher LAI was noticed in SRI method of cultivation at flowering stage crop compared to conventional transplanting and aerobic methods of cultivation during both the years (Table 1). In SRI significantly higher LAI might be due to younger (10 days old) seedling which resulted in production of high number of functional leaves. The finding of present study is inconformity with the finding of workers like Thakur *et al.* (2010) and Zheng *et al.* (2004). The treatment N_{75} (FYM) + N_{45} (Urea), being at par with N_{50} (FYM) + N_{70} (Urea), caused significantly more LAI compared to remaining treatments at 50% flowering stage during 2011.These difference was disappeared during 2011. These results are in line with the findings of Dobermann and Frairhurst (2000). However conventional transplanting method caused significantly more shoot dry matter per unit area compared to aerobic method but at par with SRI. There was no significant differences were observed in shoot dry matter at 50 % flowering stage among different INM treatments in both the years. However, more shoot dry weight was observed in N_{75} (FYM) + N_{45} (Urea) followed by N_{25} (FYM) + N_{95} (Urea) and N_{50} (FYM) + N_{70} (Urea). The root volume per hill was significantly higher due to SRI method compared to remaining methods of establishment (Table 1). In the aerobic method, the root volume was significantly higher than conventional transplanting at 50% flowering stages during both the years. The significantly higher root volume (34.0 and 34.5 / cm^3 in 2010 and 2011) was observed in SRI compared to conventional transplanting and aerobic method of cultivation of the rice in the present study. Unflooded conditions, combined with mechanical weeding, resulted in more air in the soil and greater root growth for better access to nutrients under SRI compared with conventional transplanting. Such conditions would also support more aerobic soil biota. Mechanical weeding with conoweeder increased soil aeration by dissolving oxygen in water, thus increased root growth. Moreover, the young seedlings contain more N and starch

Table 1: Growth parameters of rice as influenced by establishment methods and sources of Nitrogen

Treatment	Plant height(cm) at maturity		LAIAt booting stage		Shoot dry matterAt 50% flowering		Root volume/hillAt 50%flowering	
	2010	2011	2010	2011	2010	2011	2010	2011
Establishment Methods								
CT	122.2	126.5	4.53	4.76	971	989	17.7	19.8
SRI	131.6	136.0	5.0	5.41	932	976	34.0	34.5
Aerobic	119.2	124.3	4.27	4.36	900	914	20.8	24.4
S.Em.±	2.65	2.3	0.09	0.09	15.7	15.6	0.6	1.0
CD(0.05)	9.1	8.1	0.13	0.31	54	54	2.0	3.6
Integrated N- management								
N25(FYM)+ N95(Urea)	122.9	127.9	4.49	4.79	921	952	24.4	25.8
N50(FYM)+ N70(Urea)	123.6	129.6	4.70	4.90	930	972	25.0	27.2
N_{75}(FYM)+N_{45}(Urea)	128.9	133.8	4.91	5.18	983	978	25.5	28.0
N120(Urea)	122.0	127.0	4.32	4.50	905	937	21.8	23.9
S.Em.±	1.35	1.41	0.14	0.14	27.2	28.8	0.9	0.8
CD(0.05)	3.9	4.1	0.20	0.40	NS	NS	2.5	2.5

Table 2: Panicles/m², filled spikelets/panicle, 1000 grain weight, grain and straw yields of rice as influenced by crop establishment methods and sources of Nitrogen

Treatment	No. of panicles/m²		Filled spikelets / panicle		Grain wt. / panicle (g)		1000-grain weight (g)		Grain yield (t/ha)		Straw yield (t/ha)	
	2010	2011	2010	2011	2010	2011	2010	2010	2010	2011	2010	2011
Establishment Methods												
CT	246	278	81	89	2.28	2.41	28.25	28.3	4.79	5.01	5.96	6.09
SRI	210	218	99	121	2.82	3.34	28.6	29.0	5.26	5.71	5.80	5.90
Aerobic	236	262	76	89	2.15	2.5	28.23	28.27	4.6	4.65	5.77	5.80
S.Em.±	0.04	0.03	1.2	1.6	0.036	0.06	0.076	0.151	0.054	0.068	0.11	0.06
CD(P=0.05)	13.0	11.0	4.0	6.0	0.12	0.21	0.26	0.52	0.18	0.24	NS	0.20
Integrated N-management												
N_{25}(FYM)+N_{95}(Urea)	229	251	84	98	2.38	2.74	28.31	28.44	4.82	5.04	5.79	5.80
N_{50}(FYM)+N_{70}(Urea)	234	256	87	100	2.42	2.75	28.33	28.69	4.93	5.21	5.88	5.94
N_{75}(FYM)+ N_{45}(Urea)	237	261	86	100	2.47	2.84	28.63	28.92	5.02	5.32	6.02	6.14
N_{120}(Urea)	224	243	84	100	2.4	2.68	28.11	28.05	4.74	5.0	5.72	5.80
S.Em.±	0.03	0.04	1.0	1.6	0.034	0.062	0.109	0.160	0.043	0.006	0.01	0.01
CD(P=0.05)	10.0	12.0	NS	NS	NS	NS	0.3	0.5	0.19	0.20	NS	0.25

CT- conventional transplanting; SRI- System of rice intensification

which helped in producing more number new roots, better root growth (Rao and Raju, 1987). Higher root volume in SRI were also reported by Thakur *et al.* (2010), Velliangiri *et al.* (2011). The seedlings were planted at narrow spacing (20 x 10cm) because of which plants competed with one another for nutrients, water, solar radiations, CO_2 and space and other resources, probably resulted in poor root growth in conventional transplanting. Higher root volume also found in aerobic rice in comparison conventional transplanting due to proper supply of oxygen to the roots. Kato and Okami (2010) also found that the two morphological components of the rice system, *i.e* adventitious root emergence and lateral root proliferation were down regulated under aerobic culture conditions, resulting in a significant decrease in total root length in this method. The treatment N_{75} (FYM) + N_{45} (Urea) caused the significantly higher root volume per hill as compared to N_{120} (urea) but *at par* with the rest of treatment. N_{120} (Urea) registered the lowest root volume per hill (21.8 in 2010 and 23.9/ cm³ in 2011).

Yield attributes

Numbers of panicles/m², filled spikelets/panicle, grain weight/ panicle and 1000 grain weight were significantly influenced by different rice establishment methods (Table 2). The conventional transplanting registered significantly higher number of panicles/m² than SRI; however it was *at par* with aerobic. SRI significantly enhanced the number of grains/ panicle during both the years except during 2010 where it was *at par* with conventional transplanting method. The lowest number of filled spikelets/m² was due to aerobic method which was comparable with conventional transplanting during 2010 and significantly less as compared conventional transplanting during 2011. SRI significantly enhanced the grain weight/ panicle in comparison to conventional transplanting and aerobic. There was no significant difference observed in grain weight/panicle between conventional and aerobic rice cultivation during, 2011. While during 2010, the grain weight/ panicle was significantly lower under aerobic method compared to conventional and SRI. Significantly lowest sterility percentage was observed in SRI and higher in aerobic method compared to conventional methods during both the years. However, there was no difference in thousand grain weight under conventional transplanting and aerobic methods during both the years.

The treatment consisting of N_{50} (FYM) + N_{70} (Urea) kg /ha and

Table 3: Total nutrient uptakes (grain + straw) by rice as influenced by crop establishment methods and sources of Nitrogen

Treatment	Total nutrient uptake (kg/ha) by rice					
	N	P	K			
	2010	2011	2010	2011	2010	2011
Establishment Methods						
CT	92.1	97.7	22.5	26.0	108.2	112.8
SRI	99.4	107.6	27.1	31.0	128.4	132.9
Aerobic	87.6	89.0	21.4	21.9	100.0	102.2
S.Em. ±	0.93	1.42	0.26	0.58	1.13	1.07
CD(P=0.05)	3.20	4.90	0.89	2.0	3.9	3.7
Integrated N-management						
N_{25}(FYM)+N_{95}(Urea)	91.3	95.1	23.0	25.4	110.2	112.5
N_{50}(FYM)+N_{70}(Urea)	93.3	99.2	23.9	27.1	114.9	118.3
N_{75}(FYM)+ N_{45}(Urea)	98.9	104.8	25.6	30.2	121.2	124.8
N_{120}(Urea)	88.6	93.3	22.1	23.8	106.5	108.1
S.Em. ±	1.12	1.13	0.47	0.69	2.8	2.90
CD(P=0.05)	4.8	3.3	1.36	2.0	8.05	8.4

CT- conventional transplanting; SRI- System of rice intensification

Table 4: Soil fertility at the end of two years cropping cycle of rice as influenced by rice crop establishment methods and source of Nitrogen applied in rice

Treatment	OC	Av. N	Av. P	Av K
Establishment Methods				
CT	1.02	225.9	19.29	237.2
SRI	1.03	240.0	20.9	242.2
Aerobic	1.01	225.0	18.3	234.4
S.Em. ±	0.14	3.3	0.36	3.0
CD(P=0.05)	NS	11.3	1.24	10.3
Integrated N-management				
N_{25}(FYM)+N_{95}(Urea)	1.03	232.7	19.1	236.8
N_{50}(FYM)+N_{70}(Urea)	1.05	238.3	20.1	241.2
N_{75}(FYM)+ N_{45}(Urea)	1.06	245.7	20.4	244.3
N_{120}(Urea)	0.97	206.9	17.8	229.4
S.Em. ±	0.21	3.3	0.34	2.7
CD(P=0.05)	0.06	9.5	1.0	8.0
Initial value	0.98	220	17.8	225.0

CT- conventional transplanting; SRI- System of rice intensification

N_{75} (FYM) + N_{45} (Urea) kg /ha being *at par* with N_{25} (FYM) + N_{95} (Urea) caused similar panicles/m^2 but these values were significantly higher than treatment N_{120} (urea), during both the years. In both the years, varying proportion of FYM with conjunction of nitrogen through urea had not significant effect on number of spikelets/panicle. Highest filled spikelets/m^2 were recorded with treatments, N_{75} (FYM) + N_{45} (urea) which was statistically significant than N_{25} (FYM) + N_{95} (urea) and N_{120} (urea) in both the years but *at par* with N_{50} (FYM) + N_{70} (Urea). The lowest filled spikelets/ m^2 were obtained in N_{120}(urea). The lowest sterility percentage was obtained in treatment N_{75} (FYM) + N_{45} (urea) kg/ha which was significantly lower as compared to N_{25} (FYM) + N_{95} (urea) and N_{120} (Urea) in 2010 and N_{25}(FYM) + N_{95}(urea), N_{50}(FYM) + N_{70}(urea) and N_{120}(urea) in 2011 and was *at par* with N_{50}(FYM) + N_{70}(urea) in 2010. Significant difference was not observed in grain weight/panicle due to variable proportion of FYM integrated with N(urea) however, application of N_{75}(FYM) + N_{45}(urea) treatment caused highest grain weight/panicle during both the years. Among the INM treatments, N_{75}(FYM) + N_{45}(urea) caused the highest 1000-grain weight which was statistically significant over N_{120} in 2010 and N_{25} (FYM) + N_{95} (urea) and N_{120} in 2011 but *at par* with N_{50}(FYM) + N_{70}(urea) in 2010. This improvement in panicles/m^2, spikelets/panicle and panicle weight with combined application of FYM and fertilizer was observed due to better root growth and tillering of rice. In SRI method younger seedlings were used which established quickly and developed with high photosynthetic activity might have enhanced the yield attributes as found by Senthilkumar (2002). In SRI planting method Hossain *et al.* (2003) has also reported longer panicles, higher number of grains per panicle and 1000-grain weight.

Grain and straw yields of rice

Grain yield is a function of growth and yield attributing parameters. Grain yield is the main criterion for judging the comparative efficacy of different treatments. The grain yield of rice was significantly influenced by different method of rice establishment (Table 2). Among the different rice production methods, the system of rice intensification (SRI) caused significantly higher and aerobic caused significantly lower compared to remaining methods in both the years. Under SRI, 9.8% (in 2010) and 14.2 % (in 2011) increase in grain yield was noticed as compared to conventional transplanting. As compared to conventional transplanted rice, the aerobic cultivation lowered the grain yield by 4.1 % in 2010 and 7.7 % in 2011.

In general higher grain yield was obtained in 2011 than 2010. This might be due to favorable weather condition like more rainfall (2007mm) received by the crop and was evenly distributed throughout growing period in comparison to that in 2010. With SRI management, the main factor responsible for the yield enhancement in these trials were more filled grains per panicle and a significant increase in grain weight. On the other hand, in conventional transplanting and aerobic methods, a greater percentage of shorter panicles were noticed. Essentially, SRI practices create more favorable soil-water-plant-atmosphere relationship than are achieved under conventional wetland rice production. The improvement in grain yield under SRI practice was mainly due to improved morphology and physiological features of rice plant below and above the ground surface (Velliangiri *et al.,* 2011).

Among the nutrient sources highest grain yield was noticed due to N_{75} (FYM) + N_{45} (urea) during both the years. This was significantly more compared to remaining treatments during 2010, while during 2011, N_{75} (FYM) + N_{45} (urea), being *at par* with N_{50} (FYM) + N_{70} (urea), caused significant increase in grain yield compared to remaining treatments. Application of 120 kg N (Urea)/ ha remained *at par* with N_{25} (FYM) + N_{95} (urea) but caused significantly less grain yield compared to remaining treatments during both the years. Significant increase of grain yield in N_{75} (FYM) + N_{45} (urea) may be due to the contribution of yield components such as productive tillers/ plant, number of grains/panicle, grain weight/panicle and 1000- grain weight. It might be due to regulated supply of N to rice crop through slow mineralization process of FYM and by way of providing good physical condition for plant growth (Nambiar and Abrol, 1989). The supply of required nutrients through FYM and inorganic source facilitated balanced nutrition to the crop which resulted in enhanced grain yield in rice.

NPK uptake

The NPK differed significantly due to different treatments. Nutrient uptake being a function of dry matter production and partly its concentration, among establishment methods. Significantly higher uptake of total nitrogen, phosphorus and potassium by the rice crop was noticed in SRI method of cultivation as compared to the aerobic and conventional transplanting methods (Table 3). The better soil conditions that are favourable for the mycorhizal fungi and many soil microbes, which enhances the nutrient uptake by rice in SRI. Belder *et al.* (2005) also reported relatively low uptake of nitrogen under aerobic conditions compared to flooded conditions, which was reflected by the relatively low fertilizer-N recovery under aerobic conditions. Among the INM treatments, the N_{75} (FYM)+N_{45}(Urea) realized significantly higher NPK uptake than rest of the treatments but at par with N50(FYM)+ N70(Urea) in K uptake. Increased uptake of nutrients was observed with the application of N_{75}FYM + N_{45} Urea. The supply of timely required nutrients through N_{75} FYM + N_{45} Urea might have supplied balanced nutrition, which resulted in enhanced nutrient uptake. Another possible reason could be due to more proliferation of roots in N_{75} (FYM) + N_{45} (Urea) as compared to N_{120} (Urea), which could have tapped more volume of soils and thus total uptake of other nutrients might have also increased (Bhardwaj, 1983). Addition of FYM with enhanced nutrient uptake might be due the fact that FYM by making linkages with a part of nutrient elements and prevented them from leaching and other losses. The increased uptake of N and P might have helped to extract more K from the soil, has been evidenced by Balamurali (2006).

Soil Fertility

Soil organic carbon content was 0.98% at the initiation of the experiment. In general higher organic carbon content was observed in 2011 in comparison to 2010 (Table 4). More organic carbon content was under SRI and least in aerobic cultivation method. The SRI plots recorded significantly higher available nitrogen, phosphorus and potassium as compared to aerobic and conventional transplanting during both the years of study.

Application of N_{75} (FYM) + N_{45} (urea), caused more organic carbon content which was comparable to rest of the treatments. In 2011, significant differences in to value of organic carbon were noticed due to N_{75} (FYM) + N_{45} (urea) compared to N_{120} (urea) but all other treatments were *at par* with N_{75} (FYM) + N_{45} (Urea). The highest amount of available N, P and K were recorded due to application of N_{75} (FYM) + N_{45} (urea) which was significantly superior to N_{120} (urea) and N_{25} (FYM) + N_{95} (urea) but *at par* with N_{50} (FYM) + N_{70} (urea) in both years. The conjunctive use of chemical fertilizers and FYM has significantly improved the soil organic carbon by 17.07%, and available N, P, K by 12.9%, 10.3%, and 8.89%, respectively, over the inorganic fertilizer alone as reported by Chaterjee *et al.* (2014).

It may be concluded that system of rice intensification provided perceptible gains in productivity and income over conventional method. Integrated nutrient management comprising of 75 kg N through FYM + 45 kg N through urea/ ha under SRI seems to be the viable option to realize higher yields under rice vis-'a-vis avoids deterioration of soil fertility.

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