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Evaluation of Systems of Cultivation and Nutrient Management Practices on Yield Attributing Characters and Yield of Rice

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ABSTRACT: A field study was conducted during kharif and rabi seasons of 2011-12 and 2012-13 at research farm of Indian Institute of Rice Research (formerly DRR), Hyderabad to evaluate the performance of different systems of cultivation under different nutrient management practices. The treatment consisted of four systems of cultivation *i.e.,* system of rice intensification (SRI), modified drum seeder with 25 × 25cm spacing, normal drum seeder and conventional transplanting in main plots and four nitrogen management practices *i.e.,* 100 % RDN (recommended dose of nitrogen) through inorganic, 75 % RDN through inorganic+ 25% RDN through organic, 50 % RDN through inorganic + 50% RDN through organic and 100 % RDN through organic in sub plots. Experimental data revealed that SRI recorded significantly superior yield attributing characters *i.e.,* higher panicles number meter^{-2}, total grains number panicle^{-1}, filled grains panicle^{-1} and lower spikelet sterility (%) compared to other establishment methods during all the seasons of experiment. Significant higher grain and straw yield was recorded with SRI followed by modified drum seeder, normal drum seeder and conventional transplanting. Under different nutrient management practices 50% inorganic + 50% organic treatment registered higher panicles number meter^{-2}, filled grains panicle^{-1}, lower spikelet sterility (%), grain and straw yield as compared to remaining nutrient management practices during all the four seasons of data.

Keywords: SRI, modified drum seeder, sterility percentage, INM, grain yield.

INTRODUCTION

Rice is the staple food for a large part of the human population. Globally, for 40 % of the population rice (*Oryza sativa* L.) is the major source of energy (Baishya *et al.,* 2015) and supplies as much as 50% of the daily calories (Abbasi *et al*., 2011). Annually in India, around 120 million tonnes of rice is produced in an area of 44 million hectares with a productivity of over two tonnes per hectare of milled rice.

About 77% of the global rice production in the world is produced by practicing conventional transplanting method in puddled soil (Chakraborty *et al*., 2017; Xu *et al*. 2019). Conventional transplanting system of rice crop production requires water, labour, energy and capital in large amount so that it has become less profitable at present due to the lack of these resources (Guruprem *et al*., 2017). Transplanting takes roughly 25% of the total labour requirement of the crop.A shortage of labour during peak period causes delayed transplanting, it leads to increasing transplanting shock and lower productivity. Increased cost of rice cultivation was observed in conventional methods due to decreased availability and increasing cost of labour. All these factors demand a major shift from conventional transplanted rice production to wet direct seeding of rice.

Direct seeding on puddled soil avoids drudgery of nursery raising and transplanting. It saves time and investment compared to transplanting. Absence of nursery management and transplanting operation, less labour requirement, reduction in methane emission, increased water use efficiency and higher profitability are the advantages of direct seeding compared to transplanted rice (Chauhan *et al*., 2012). Risk of terminal drought can avoided by practicing direct seeded rice as it matures 1-2 weeks earlier than transplanted rice and it also allows earlier sowing of a following non-rice crop (Rana *et al*., 2014).

In India after green revolution cultivation of high yielding dwarf varieties took place. These HYVs are responsive to fertilizer. To meet the nutrient needs of these high yielding varieties farmers become depended on application of chemical fertilizers. Increased use of the chemical fertilizers leads higher rice yields and biomass production (Ghosh *et al.,* 2013). Inherent soil fertility was badly effected with excess use of inorganic fertilizers. The decline or stagnation in yield has been observed in spite of application of increased rate of chemical fertilizers. Data analysis of the long-term studies all over the country revealed that in spite of continuous use of chemical fertilizers also a decrease in rice productivity was observed (Baishya *et al.,* 2015). Organics can improve yield and nutrient use efficiency of rice (Singh and Kumar 2014). Nutrients demand at the peak period can be met through organics. Organic manures also acts as source for micro nutrients and increase the efficiency of applied nutrients by modifying the soil-physical behavior. The combined application of organic manures and inorganic fertilizers not only supply the nutrients demanded by the crop but also helps to attain productivity goals by maintaining the sustainability of the system (Yadav and Meena 2014).

MATERIALS AND METHODS

The present study was under taken during kharif and rabi seasons of 2011-12 and 2012-13at Indian Institute of Rice Research farm, Rajendranagar, Hyderabad. The farm is geographically situated at an altitude of 542.7 m above mean sea level on 17° 19' N latitude and 78° 29' E longitudes. The soil was clay loam, alkaline in reaction (pH 8.0-8.2), with 0.48-0.52% of organic matter, 210-223 kg ha^{-1} of available nitrogen, 39-43 kg ha^{-1} of available P and 525-542 kg ha^{-1} of available K. The experimental design was split plot design with four main plot treatments, four subplot treatments and replicated thrice. The treatment combinations consisted of four establishment methods i.e., system of rice intensification(SRI) (M_1), modified drum seeder (25 × 25cm spacing)(M_2), normal drum seeder (M_3) and normal transplanting(NTP) (M_4) in main plots and four nutrient management practices *i.e.,* 100 % RDN (recommended dose of nitrogen) through inorganic (N_1), 75 % RDN through inorganic + 25% RDN through organic (N_2), 50 % RDN through inorganic + 50% RDN through organic (N_3) and 100 % RDN through organic (N_4) in sub plots. In normal drumseeders, the spacing will be 20 × 5-8 cm. By making some alterations modified drum seeder was fabricated with spacing of 25 × 25 cm for this study to test the wider spacing efficiency in direct seeding. The high yielding, semi dwarf rice variety Sampadha, having crop duration of 135 days and yield potential of 5.8-6.8 t ha^{-1} was grown in the experimental site. The recommended dose of fertilizer was 120 Kg N: 60 Kg P_2O_5: 40 Kg K_2O ha^{-1}. In case of 100% inorganic treatment nitrogen was applied through urea in three equal splits as ½ as basal, ¼ at maximum tillering and ¼ at panicle initiation stage. In INM treatments inorganic source of nitrogen was applied through urea in three equal splits at basal, 30 DAT (days after transplanting) and at 60 DAT. The organic source of nitrogen was applied based on the nitrogen equivalent of vermicompost as basal. In case of direct seeding sprouted seeds were sown on thoroughly puddled and well leveled main field. On the same day the sprouted seeds were broadcasted uniformly on well prepared nursery bed for NTP and SRI.

RESULTS AND DISCUSSION

Number of panicles (m^{-2}). Systems of cultivation significantly influenced number of panicles $meter^{-2}$. During all the four seasons SRI exhibited significantly higher number of panicles m^{-2} than all other systems of cultivation and it was followed by modified drum seeder. It was in conformity with the findings of Jeet *et al.,* (2021); Bhat *et al.,* (2018); Dhakal *et al.*, (2017) and Bhandari *et al.*, (2020). It was also observed that normal transplanting method showed significantly lower number of panicles m^{-2} as compared toall other establishment methods. NTP recorded 43.25, 34.16, 29.16 and 38.46% lower number of panicles m^{-2} as compaped to SRI during kharif 2011, kharif 2012 and rabi 2011-12 and rabi 2012-13, respectively. These observations were in conformity with the findings of Singh *et al.* (2015).

During all the four seasons the treatment N_3 (50% Inorg + 50% Organic) noticed higher number panicles m^{-2}over other nutrient management practices and it was followed by N_1 [100% Inorganic]. The per cent increase in number of panicles noticed in N_3 [50% Inorg + 50% Organic] (10.0, 11.0 and 10.5 %), N_1 (100% Inorganic) (6.3, 8.5 and 7.4 %) and in N_2 [75% Inorganic + 25% Organic] (10.0, 11.0 and 10.5 %) was appreciable over N_3 [100% Organic] during 2011 kharif, 2012 kharif, 2011-12 rabi, 2012-13 rabi and in pooled kharif and rabi means, respectively. This might be due to integrated use of inorganic and organic sources of nutrients have resulted in enhanced nitrogen availability in the root zone resulting in enhanced N uptake by rice which ultimately helped in production of more panicles. These results are in support with Shrinivas and Krishnamurthy (2017); Bhat *et al.,* (2018); Patel *et al*., (2013).

Total number of grains $panicle^{-1}$. During all the four seasons of study it was observed that methods of planting were significantly influenced the total number of grains panicle^{-1}. Numerically higher number of grains panicle^{-1}was observed with SRI during all the four seasons. This might be attributed to wider spacing adopted in SRI resulted in more light interception that finally lead to more dry matter accumulation and partitioning into sink (panicles). These results are in accordance with the findings of Jeet *et al.,* (2021); Bhat *et al*., (2018).

Among all the nutrient management practices 50% RDN through inorganic source + 50% RDN through organic source treatment recorded significantly higher number of grains panice^{-1} over treatment N_2 (75% RDN through inorganic + 25% RDN through organic source) and treatment N_4 (100% RDN through organic source) and it was statistically on par with N_1 (100% RDN through inorganic source) during all the seasons of the study. Application of organics and inorganics in equal ratios supplies nutrients during the reproductive stage by decomposing the applied vermicompost to the rice crop. These nutrients were utilized by the plants and resulted in more number of grains panicle^{-1}. These observations were in conformity with the findings of many researchers (Bhat *et al.,* 2018; Laljiyadav and Meena 2014). Treatment 100% RDN through organic source recorded the lowest number of grains panicle^{-1}.

Number of filled grains panicle^{-1}. Number of filled grains panicle^{-1} differed significantly among planting methods during all the four seasons of study. The numerically higher number of filled grains panicle^{-1} was observed with SRI. This was due to wide spacing in SRI has resulted in more leaf area, this leaf area is the source for carbohydrate production. That more carbohydrate production maintained source sink relationship positively in producing more number of filled grains in SRI. These results are in support with the findings of Jeet *et al.* (2021); Dhakal *et al.* (2017). 50% RDN through inorganic + 50% RDN through organic source treatment recorded significantly higher number of filled grains panice^{-1} (105.8, 117.8, 105.9 and 126.8 during kharif 2011, kharif 2012, rabi 2011-12, rabi 2012-13, respectively) over treatment N_2(75% RDN through inorganic + 25% RDN through organic source) and treatment N_4 (100% RDN through organic source) and it was at par with N_1 (100% RDN through inorganic source) during all the seasons of study. This might be due to conjunctive application of organics and inorganics in equal quantity supplied nitrogen as and when needed to crop and this improved N supply contributing to enhanced N uptake by the plant. Increased N uptake resulted in more dry matter production and its translocation from source to sink. Similar observations were also reported by Mangaraj *et al.,* (2022). Treatment N_4 (100% RDN through organic source) recorded the lowest number of filled grains panicle^{-1} (74.3, 90.3, 88.9 and 99.3 during kharif 2011, kharif 2012, rabi 2011-12, rabi 2012-13, respectively).

Spikelet sterility (%). During both the years of study planting methods and nutrient management practices significantly influenced the spikelet sterility percentage (Table 4). The mean spikelet sterility percentage of rice was 16.11, 16.28 and 16.19 % during kharif seasons of 2011, 2012 and in pooled mean respectively, 12.98, 13.66 and 13.32% during rabi seasons of 2011, 2012 and in pooled mean respectively.

The lowest spikelet sterility percentage was observed in SRI method of planting as compared to modified drumseeder (13.12, 18.51, 12.06, 13.01, 15.82 and12.53 %), normal drumseeder (18.56, 13.98, 14.47, 16.04, 16.27 and 15.26%) and normal transplanting (23.30, 21.65, 17.47, 17.73, 22.48 and 17.60%) during kharif and rabi seasons of 2011-12 & 2012-13 and in pooled means, respectively. This could be due to closer spacing adopted in in normal drum seeder and in normal transplanting lead to intense shading and greater competition between plants and resulted in less nutrient uptake. These observations were in agreement with the findings of Jeet *et al.,* (2021); Dhakal *et al.,* (2017); Bhandari *et al.*, (2020).

During both the years of study significantly lower spikelet sterility percentage of rice was registered with 50% RDN through inorganic + 50% RDN through organic source than all other nutrient management practices. Among all the nutrient management treatments 100% RDN through organic source registered highest sterility percentage of 21.58, 20.38, 16.93 and 18.71% during kharif 2011, kharif 2012, rabi 2011-12 and rabi 2012-13 respectively. This was probably due to more vegetative growth and secondary tillers and less partitioning of biomass to the reproductive parts due to less availability of N at grain filling phase of the crop. These results are in agreement with the findings of Harish *et al.* (2011).

1000 grain weight (g). The mean 1000 grain weight of rice was 19.39, 20.11 and 19.75 g during *kharif* seasons of 2011& 2012, 20.33, 21.81 and 21.07 g during 2011-12.

No significant influence on 1000 grain weight of rice was observed with planting methods and nutrient management practices. Among the different systems the mean higher values of test weight was observed with system of rice intensification. All the planting methods performed significantly on par in respect of 1000 grain weight and which was mainly depending on genetically inherent character of the variety. The similar results were also recorded by Jnanesha and Kumar (2017); Bhandari *et al.* (2020).

50% RDN through inorganic + 50% RDN through organic treatment recorded the numerically higher average values of test weight and it was followed by 100% RDN through inorganic source. 1000 grain weight of rice in general is a character governed by the plant genetic makeup which has been reflected in crop performance.

Grain yield (kg ha^{-1}). The higher grain yield of 6535 kg ha^{-1} & 6140 kg ha^{-1} was recorded by SRI method during 2012 & 2011 kharif seasons respectively. Next to SRI method modified drumseeder proved its significant superiority over normal drumseeder and normal transplanting. Whereas, during 2011 kharif modified drumseeder remained at par with normal drumseeder but was found significantly superior over normal transplanting normal drumseeder (Table 6). The pooled data also indicated that SRI method stood first with grain yield of 6337.5 kg ha^{-1} followed by modified drumseeder, normal drumseeder and normal transplanting. In terms of percentage increase in yield due to SRI over modified drumseeder, normal drumseeder and normal transplanting was 9.27, 18.24, 21.74% respectively. During rabi season of 2011-12 and 2012-13 SRI method was found significantly superior than the remaining three crop establishment methods. There was high yield difference of 579kg ha^{-1} and 358 kgha^{-1} between SRI and modified drumseeder in first and second rabi seasons respectively. The pooled data also showed the advantage of 468 kg ha^{-1} by SRI over modified drumseeder. These observations were in conformity with the findings of Upendrarao *et al.* (2020); Pramod *et al.,*(2021); Bhat *et al*., (2018); Dhakal *et al.,* (2017); Bhandari *et al.,* (2020).

The yield advantage due to SRI over conventional planting was mainly owing to more number of tiller productions per square meter accompanied by maximum panicle bearing tillers with low spikelet sterility. Since planting of young seedlings of 12 days in main field with immediate establishment have facilitated early initiation of tillers. It is evident that highest tillers production was observed with SRI planting. Controlled irrigation also augmented the fresh root production till flowering stage and does helped in supplementation of nutrient requires for supporting of filling capacity of panicles.

Among the nitrogen management treatments 50% RDN through inorganic + 50% RDN through organic proved its superiority during all the seasons of experiment. During first kharif season 50% RDN through inorganic+ 50% RDN through organic remained at par with 100% RDN through inorganic. But 2012 kharif data and the kharif pooled data indicated the significant superiority of 50% RDN through inorganic + 50% RDN through organic source. Both the rabi seasons data revealed that 50% RDN through inorganic + 50% RDN through organic was on par with 100% RDN through inorganic and found significantly better over remaining other treatments. The results emphasize the concepts of INM for high grain production and also sustainability of soil fertility (Amanullah and Hidayatullah 2016; Meher Malika *et al.,* 2015). During all the seasons 100% organic treatment recorded lowest grain yield (Elhabe, 2018; Mangaraj *et al.,* 2022; Bhat *et al.,* 2018).

In respect of grain yield during all the seasons of study the interaction effect of planting methods and nutrient management practices was found to be significant (Table 6a). During kharif 2011, kharif 2012, rabi2011-12, rabi 2012-13 and in kharif and rabi pooled means showed that SRI in combination with 50% RDN through inorganic source+50% RDN through organic source recorded significantly higher grain yield over other establishment and nutrient combinations.

Straw yield (kg ha^{-1}). Straw yield of rice was significantly higher in system of rice intensification and during kharif and rabi seasons of 2012-13 it was significantly on par with modified drum seeder treatment (Table 7). During all the seasons straw yield recorded by modified drum seeder was statistically on par with normal drum seeder. By observing the data of all the four seasons it was witnessed that wider spacing treatments recorded higher straw yield as compared to closer spacing treatments. It was probably due to more dry matter production per unit area caused by better nutrient absorption from soil, increased rate of metabolic processes, higher rate of light absorption and increased rate of photosynthetic activity that produced higher plant height and leaf area index as compared to normal transplanting. These results are in agreement with the findings of Upendrarao *et al*., (2020); Pramod *et al.* ,(2021); Nahar *et al.,* (2017); Bhat *et al.* (2018).

During all the four seasons highest straw yield was observed with treatment 50% RDN through inorganic source + 50% RDN through organic source. The superiority of this treatment was due to conjunctive use of organic manures and inorganic lead to adequate supply of nitrogen throughout crop growth period that resulted in higher dry matter production (Meher Malika *et al.,* 2015; Mangaraj *et al.,* 2022). The lowest straw yield was found with treatment 100% organic during all the seasons (Elhabe, 2018; Bhat *et al.,* 2018).

Fig. 1. Normal Drum seeder.

Fig. 2. Modified Drum Seeder.

 **Fig. 3.** Transplanting operation.	 **Fig. 4.** Cono weeding in SRI plots.

Table 1: Number of panicles m^{-2} of rice at harvest as influenced by establishment methods and nutrient management practices during kharif and rabi seasons of 2011-12, 2012-13 and pooled means.

Treatments	Number of panicles m^{-2} of rice at harvest						
	Kharif				Rabi		
	2011	2012	Pooled		2011	2012	Pooled
MAIN PLOTS							
M1 (SRI)	308.33	322.42	315.38		310.25	360.25	335.25
M2 (Modified Drum Seeder)	260.00	295.50	277.75		280.33	319.33	299.83
M3 (Normal Drum Seeder)	230.00	261.33	245.67		250.50	275.50	263.00
M4 (NTP)	215.25	240.75	228.00		240.25	260.50	250.38
MEAN	253.40	280.00	266.70		270.33	303.90	287.11
S.Em±	6.05	5.92	5.08		7.40	8.20	6.21
C.D. at 5%	20.95	20.48	17.57		25.60	28.37	21.49
SUBPLOTS							
N1 (100% Inorg)	270.25	293.17	281.71		292.00	324.25	308.13
N2 (75% Inorg+25% org)	233.08	260.50	246.79		244.17	282.00	263.08
N3 (50% Inorg+50% org)	311.50	340.33	325.92		320.50	362.25	341.38
N4 (100%org)	198.75	226.00	212.38		224.67	247.08	235.88
MEAN	253.40	280.00	266.70		270.33	303.90	287.11
S.Em±	8.20	9.35	6.42		5.62	10.05	5.19
C.D. at 5%	23.92	27.30	18.73		16.39	29.33	15.13
INTERACTIONS							
Sub at same level of Main							
S.Em±	16.39	18.71	12.84		11.23	20.09	10.37
CD at 5%	NS	NS	NS		NS	NS	NS
Main at same level of Sub							
S.Em±	15.43	17.25	12.22		12.22	19.24	10.92
CD at 5%	NS	NS	NS		NS	NS	NS

Table 2: Number of filled grains panicle^{-1} as influenced by establishment methods and nutrient management practices (2011-12 and 2012-13).

Treatments	Number of filled grains panicle^{-1}						
	Kharif				*Rabi*		
	2011	2012	Pooled		2011	2012	Pooled
MAIN PLOTS							
M1 (SRI)	117.0	121.0	119.0		109.5	131.0	120.3
M2 (Modified Drum Seeder)	98.0	95.0	96.5		90.4	119.0	104.7
M3 (Normal Drum Seeder)	78.3	109.0	93.6		98.7	103.0	100.8
M4 (NTP)	67.6	88.0	77.8		87.1	96.0	91.6
S.Em±	2.7	2.9	2.1		2.6	3.1	2.7
C.D. at 5%	9.3	10.0	7.3		9.0	10.8	9.3
SUBPLOTS							
N1 (100% Inorg)	95.3	107.8	101.5		97.7	116.8	107.2
N2 (75% Inorg+25% org)	85.3	97.3	91.3		93.2	106.3	99.7
N3 (50% Inorg+50% org)	105.8	117.8	111.8		105.9	126.8	116.3
N4 (100%org)	74.3	90.3	82.3		88.9	99.3	94.1
S.Em±	3.6	3.5	2.8		3.7	3.8	3.2
C.D. at 5%	10.5	10.4	8.2		10.8	11.0	9.5
GENERAL MEAN	90.2	103.3	96.7		96.4	112.3	104.3
INTERACTIONS							
Sub at same level of Main							
S.Em±	7.2	7.1	5.6		7.4	7.6	6.5
CD at 5%	NS	NS	NS		NS	NS	NS
Main at same level of Sub							
S.Em±	5.4	6.8	5.3		6.9	7.2	6.2
CD at 5%	NS	NS	NS		NS	NS	NS

Table 3: Total number of grains panicle^{-1} as influenced by establishment methods and nutrient management practices (2011-12 and 2012-13).

Treatments	Total number of grains panicle^{-1}						
	Kharif				*Rabi*		
	2011	2012	Pooled		2011	2012	Pooled
MAIN PLOTS							
M1 (SRI)	128.9	135.7	132.3		118.6	142.3	130.5
M2 (Modified Drum Seeder)	112.2	116.1	114.1		102.5	135.2	118.8
M3 (Normal Drum Seeder)	95.3	126.3	110.8		115.1	121.9	118.5
M4 (NTP)	87.4	111.8	99.6		105.5	116.9	111.2
S.Em±	2.3	3.0	2.0		2.4	3.0	2.5
C.D. at 5%	8.0	10.4	6.9		8.4	10.5	8.6
SUBPLOTS							
N1 (100% Inorg)	109.8	125.9	117.9		110.2	132.1	121.1
N2 (75% Inorg+25% org)	101.9	117.4	109.6		108.4	124.6	116.5
N3 (50% Inorg+50% org)	118.6	133.9	126.2		116.4	138.8	127.6
N4 (100%org)	93.4	112.6	103.0		106.7	120.8	113.8
S.Em±	3.7	3.7	3.0		3.7	3.8	3.2
C.D. at 5%	10.9	10.7	8.7		NS	11.2	9.2
GENERAL MEAN	105.9	122.4	114.2		110.4	129.1	119.8
INTERACTIONS							
Sub at same level of Main							
S.Em±	7.5	7.3	6.0		7.3	7.7	6.3
CD at 5%	NS	NS	NS		NS	NS	NS
Main at same level of Sub							
S.Em±	6.9	7.0	5.5		6.8	7.3	6.0
CD at 5%	NS	NS	NS		NS	NS	NS

Table 4: Sterility percentage (%) as influenced by establishment methods and nutrient management practices (2011-12 and 2012-13).

Treatments	Sterility percentage (%)						
	Kharif				Rabi		
	2011	2012	Pooled		2011	2012	Pooled
MAIN PLOTS							
M1 (SRI)	9.46	10.95	10.21		7.90	7.86	7.88
M2 (Modified Drum Seeder)	13.12	18.51	15.82		12.06	13.01	12.53
M3 (Normal Drum Seeder)	18.56	13.98	16.27		14.47	16.04	15.26
M4 (NTP)	23.30	21.65	22.48		17.47	17.73	17.60
S.Em±	0.60	0.61	0.50		0.57	0.52	0.37
C.D. at 5%	2.07	2.11	1.72		1.97	1.80	1.27
SUBPLOTS							
N1 (100% Inorg)	14.05	14.72	14.38		11.52	12.17	11.84
N2 (75% Inorg+25% org)	17.42	17.72	17.57		14.11	15.05	14.58
N3 (50% Inorg+50% org)	11.40	12.28	11.84		9.34	8.72	9.03
N4 (100%org)	21.58	20.38	20.98		16.93	18.71	17.82
S.Em±	0.72	0.66	0.44		0.52	0.57	0.49
C.D. at 5%	2.11	1.94	1.29		1.51	1.67	1.44
GENERAL MEAN	16.11	16.28	16.19		12.98	13.66	13.32
INTERACTIONS							
Sub at same level of Main							
S.Em±	1.44	1.33	0.88		1.03	1.14	0.98
CD at 5%	NS	NS	NS		NS	NS	NS
Main at same level of Sub							
S.Em±	1.39	1.30	0.91		1.06	1.12	0.93
CD at 5%	NS	NS	NS		NS	NS	NS

Table 5: 1000 grain weight (g) as influenced by establishment methods and nutrient management practices (2011-12 and 2012-13).

Treatments	1000 grain weight (g)						
	Kharif				Rabi		
	2011	2012	Pooled		2011	2012	Pooled
MAIN PLOTS							
M1 (SRI)	21.18	22.20	21.69		21.24	22.48	21.86
M2 (Modified Drum Seeder)	18.85	20.78	19.81		19.60	21.98	20.79
M3 (Normal Drum Seeder)	19.68	19.18	19.43		21.31	21.72	21.51
M4 (NTP)	17.88	18.29	18.08		19.18	21.08	20.13
S.Em±	0.68	0.87	0.72		0.52	0.53	0.32
C.D. at 5%	NS	NS	NS		NS	NS	NS
SUBPLOTS							
N1 (100% Inorg)	19.58	20.8	20.19		20.53	22.25	21.39
N2 (75% Inorg+25% org)	18.78	19.2	18.99		19.74	21.55	20.65
N3 (50% Inorg+50% org)	20.83	21.85	21.34		21.80	22.80	22.30
N4 (100%org)	18.39	18.59	18.49		19.26	20.64	19.95
S.Em±	0.66	0.89	0.74		0.75	0.56	0.56
C.D. at 5%	NS	NS	NS		NS	NS	1.39
GENERAL MEAN	19.39	20.11	19.75		20.33	21.81	21.07
INTERACTIONS							
Sub at same level of Main							
S.Em±	1.33	1.79	1.47		1.51	1.12	1.12
CD at 5%	NS	NS	NS		NS	NS	NS
Main at same level of Sub							
S.Em±	1.34	1.78	1.47		1.40	1.11	1.02
CD at 5%	NS	NS	NS		NS	NS	NS

Table 6: Grain yield (kg ha^{-1}) as influenced by establishment methods and nutrient management practices.

practices						
Treatments	**Kharif**			**Rabi**		
MAIN PLOTS	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**
M1 (SRI)	6140	6535	6338	6438	6645	6541
M2 (Modified Drum seeder)	5356	6244	5800	5859	6287	6073
M3 (Normal Drum Seeder)	5084	5635	5359	5392	6090	5741
M4 (NTP)	4944	5468	5206	5356	6025	5690
S.Em±	137	138	34	112	117	47
C.D. (*P=.05*)	475	477	117	388	405	162
SUBPLOTS						
N1 (100% Inorg)	5363	6124	5743	5898	6408	6153
N2 (75% Inorg+25% org)	5300	5827	5563	5591	6203	5897
N3 (50% Inorg+50% org)	5693	6383	6038	6033	6457	6245
N4 (100%org)	5168	5547	5358	5523	5980	5751
S.Em±	107	92	67	108	106	86
C.D. (*P=.05*)	311	269	196	316	309	252
GENERAL MEAN	5381	5970	5676	5761	6262	6011
INTERACTIONS						
Sub at same level of Main						
S.Em±	213	185	134	216	211	173
CD (*P=.05*)	622	539	391	631	617	505
Main at same level of Sub						
S.Em±	230	211	121	218	217	157
CD (*P=.05*)	716	665	358	669	668	465

Table 6a: Interaction of crop establishment methods and nutrient management practices on grain yield (kg ha^{-1}).

	Kharif 2011					Kharif 2012					Kharif pooled mean				
Establishment methods	N_1	N_2	N_3	N_4	**Mean**	N_1	N_2	N_3	N_4	**MEAN**	N_1	N_2	N_3	N_4	**MEAN**
M1-SRI	6292	6092	6762	5414	6140	6974	6821	6523	5822	6535	6556	6307	6868	5618	6337
M2- Modified drum seeder	5482	4942	5749	5249	5356	6643	6625	5872	583	6244	6053	5407	6196	5542	5799
M3- Normal drum seeder	4753	5451	4910	5222	5084	6221	5929	5539	4851	5635	5341	5494	5565	5036	5359
M4- NTP	4923	4714	5351	4787	4944	5695	5121	5375	5681	5468	5022	5044	5522	5233	5205
MEAN	5363	5300	5693	5168		6383	6124	5827	5547		5743	5563	6038	5357	
	S.Em ±		CD (*P*=.05)			S.Em ±		(*P*=.05)			S.Em ±		CD at (*P*=.05)		
Sub at same level of main	213		622			185		539			134		391		
Main at same level of sub	230		716			211		665			121		358		

	Rabi 2011-12					Rabi 2012-13					Rabi pooled mean				
Establishment methods	N_1	N_2	N_3	N_4	**MEAN**	N_1	N_2	N_3	N_4	**MEAN**	N_1	N_2	N_3	N_4	**MEAN**
M1-SRI	6534	6310	7090	5817	6438	7058	6646	7073	5801	6645	6796	6478	7081	5809	6541
M2- Modified drum seeder	6079	6018	6055	5283	5859	6363	6041	6603	6141	6287	6220	6029	6329	5711	6072
M3- Normal drum seeder	5416	4953	5315	5882	5392	6433	5995	6023	5907	6090	5924	5474	5669	5894	5740
M4- NTP	5562	5082	5670	5109	5356	5777	6128	6127	6069	6025	5669	5604	5898	5589	5690
MEAN	5898	5591	6033	5523		6408	6203	6457	5980		6152	5896	6244	5751	
	S.Em ±		CD at (*P*=.05)			S.Em ±		CD at (*P*=.05)			S.Em ±		CD at (*P*=.05)		
Sub at same level of main	216		631			211		617			173		505		
Main at same level of sub	218		669			217		668			157		465		

Table 7: Straw yield (kg ha^{-1}) of rice as influenced by establishment methods and nutrient management practices means.

	Kharif			Rabi		
MAIN PLOTS	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**
M1 (SRI)	7188.08	7542.75	7365.42	7342.08	7652.58	7497.33
M2 (Modified Drum Seeder)	6109.92	6956.08	6533.00	6679.17	7121.67	6900.42
M3 (Normal Drum Seeder)	5793.08	6480.75	6136.92	6083.42	6539.33	6311.38
M4 (NTP)	5278.08	5974.58	5626.33	5759.00	6302.17	6030.58
S.Em±	140.83	185.79	123.59	155.42	195.07	126.46
C.D. at 5%	487.35	642.92	427.68	537.81	675.04	437.62
SUBPLOTS						
N1 (100% Inorg)	6138.33	6922.25	6530.29	6588.42	7044.25	6816.33
N2 (75% Inorg+25% org)	5996.17	6545.25	6270.71	6313.42	6749.17	6531.29
N3 (50% Inorg+50% org)	6617.25	7393.67	7005.46	7026.00	7486.33	7256.17
N4 (100%org)	5617.42	6093.00	5855.21	5935.83	6336.00	6135.92
S.Em±	131.83	158.55	92.02	147.15	170.44	106.65
C.D. at 5%	384.78	462.77	268.58	429.50	497.49	311.28
General Mean	6092.29	6738.54	6415.42	6465.92	6903.94	6684.93
INTERACTIONS						
Sub at same level of Main						
S.Em±	263.66	317.10	184.04	294.30	340.89	213.30
CD at 5%	NS	NS	NS	NS	NS	NS
Main at same level of Sub						
S.Em±	268.28	331.56	201.68	298.52	353.85	223.86
CD at 5%	NS	NS	NS	NS	NS	NS

CONCLUSION

In conclusion from the above study, wider spacing in SRI recorded superior yield attributing characters and higher yield. Among nutrient management practices 50% RDN through inorganic + 50% RDN through organic source was found to be superior in all the yield attributing characters and yield. Interaction effect revealed that SRI in combination with 50% RDN through inorganic source + 50% RDN through organic recorded significantly higher grain yield over other establishment and nutrient combinations.

FUTURE SCOPE

The issues of labour and water scarcity getting worse day by day, hence, there is need for fine tuning of SRI and drumseeders for wider adaptability. Identifying the implementable technology to resolve the labour and water issues is need of the hour. There is need for long term evaluation on effect of different crop establishment methods. In integrated nutrient management practices, *Azolla* can also be tried as one of the organic source.

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