Effect of Establishment Methods and Nutrient Management Practices on Growth Characters and Yield of Rice (*Oryza sativa* L.)

ABSTRACT

Aim: Study was conducted to compare and to identify the best combination of rice crop establishment method and nutrient management in terms of crop growth, development and yield.

Study design: Experiment was laid out in splitplot design.

Place and Duration of Study: The field experiments were conducted at the research farm of Indian Institute of Rice Research, Hyderabad, Telangana State, India during the kharif and rabi seasons of 2011-12 and 2012-13.

Methodology: The treatments consisted of four establishment methods (System of rice intensification (SRI), modified drumseeder, normal drumseeder and normal transplanting) as main plot treatments and four nutrient management practices (100% RDN through inorganic, 75% RDN through inorganic+ 25% RDN through organic, 50% RDN through inorganic+50% RDN through organic and 100% RDN through organic) as sub plot treatments with 16 treatment combinations with three replications. Sampada variety was cultivated.

Results: Growth parameters i.e., plant height, leaf area index (LAI), drymatter accumulation, number of tillers per square meter were observed at 45,75,105 and harvest stages. The two years experimental results and the pooled mean data revealed that SRI recorded significantly superior growth parameters at all the crop growth stages followed by modified drum seeder. In respect of subplots 50% RDN through inorganic+50% RDN through organic resulted in superior growth parameters and yield.

Conclusions: The combination of SRI and 50% RDN through inorganic+50% RDN through organic resulted in greater growth parameters and grain yield.

Key words: SRI, direct seeding, modified drumseeder, INM

INTRODUCTION:

Rice is the staple nourishment of over half of the world's population. It is the excellent dietary vitality source for seventeen nations in Asia and the Pacific, nine nations in the north and South America and eight nations in Africa [1]. It is the major source of calories for 40% of the world population [2]. About 77% of the global rice production in the world is done by conventional transplanting methods in puddled soil [3] [4]. Conventional transplanting system of rice crop production requires labour, water, capital, and energy in large amount so that it has become less profitable at present due to the lack of these resources [3] [5]. A shortage of labour during peak periods increase labour wages and make transplanting operation costly [6]. Thus, the farmers prefer direct seeding method as a viable alternative to the drudgery and labour intensive conventional transplanting system.

Direct seeding probably is one of the oldest method of crop establishment which is now practiced in many Asian countries [7]. Direct rice seeding has many advantages to the farmers such as higher economic returns, faster and easier technology, less labour and water requiring, suitable for mechanization, short crop duration and have less methane emission [8] [9].

Another major concern in rice production systems is the dwindling trend of availability of water resources [10]. Out of 70-80% freshwater used in agriculture, rice accounts for 85% in total and 30% in puddling only. A 10% increase in irrigation efficiency can help bring additional 14 million ha area under irrigation [11]. Hence there is need to develop and adopt water saving methods in rice cultivation so that production and productivity levels are elevated despite the looming water crisis [11] [12]. SRI method has found to save 22 to 38 per cent of water respectively during dry and wet season over other method of rice establishment [13]. Efficient natural resource management and nutrients could be better utilized under SRI along with integration of nutrient sources to realize the maximum rice crop productivity through enhancing growth and physiological aspects of low land rice [14].

Intensive agriculture and decreasing the use of organic material, have led to severe degradation of soil fertility and productivity of rice cropping systems [15]. The decline or stagnation in yield has been attributed to nutrient mining and reduced use of organics [16]. Under high input production systems where productivity cannot be further increased with incremental use of mineral fertilizers alone, addition of organic sources could increase yields through increased soil productivity and higher fertilizer use efficiency [17] [18] [19]. [20] reported increased yield and nutrient use efficiency in rice with organics. The combined use of organic and inorganic fertilizers has been reported not only to meet the nutrients need of the crop but also has been fund to sustain large scale productivity goals [21]. A synergistic effect on crop yield is reported through common use of fertilizer and organics has improved soil fertility. Integrated nutrient management involves maintenance of soil fertility, sustainability of crop production and the beneficial effect of integrated plant nutrient supply(IPNS) in low land rice has been well reported by several workers [22].

2. Materials and Methods

The present investigation was conducted during kharif and rabi seasons of 2011-12 and 2012-13 at Indian Institute of Rice Research farm, Rajendranagar, Hyderabad, Telengana state, India. 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. According to Troll's climatic classification, it falls under semi-arid tropics (SAT). 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 semi dwarf, high yielding rice variety Sampadha, having crop duration of 135 days with yield potential of 5.8-6.8 t $ha^{-1}$was grown in the experimental site. Usually normal drum seeders are available with close spacing (20×5-8 cm^2), but for this study a new drumseeder was fabricated with 25X25 cm^2 spacing to test the wider spacing efficiency in direct seeding. And this treatment was denoted as modified drumseeder. The experiment was laid out in splitplot design with sixteen treatments and three replications. The treatment combinations consisted of four establishment methods i.e., system of rice intensification(SRI) (M_1), modified drumseeder (25×25cm^2 spacing)(M_2), normal drumseeder (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 case of NTP and SRI the sprouted seeds were broadcasted uniformly in well prepared seed beds. And on the same day seeds were sown in the respective main field plots for drumseeder and modified drumseeder. The recommended dose of fertilizer was 120 Kg N: 60 Kg P_2O_5 : 40 Kg K_2O ha^{-1}.The recommended dose of phosphorus @ 60 kg P_2O_5 kg ha^{-1} through single super phosphate (SSP), potassium @ 40 kg K_2O ha^{-1} as muriate of potash (MOP) and $ZnSO_4$@ 20 kg ha^{-1}were applied to all the treatments uniformly as basal. 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. Twelve days and twenty one days old seedlings were used for transplanting in SRI and NTP respectively. Spacing of 25x25$cm^2$was maintained in SRI and modified drumseeder methods and for NTP it was 20x15 cm^2.

3. RESULTS AND DISCUSSION

3.1. Plant height

During both the years, an average plant height increased linearly up to 105 DAS and continued to increase until maturity at a diminishing rate. During both the years of the study, plant height recorded significantly higher in system of rice intensification (SRI) and it was followed by modified drum seeder at all the crop growth stages over normal drumseeder and NTP (Table 1). Taller plants resulted by adopting SRI method might be due to transplanting of younger and single seedling by keeping the roots straight (ensuring that the roots do not assume 'J' shape). Wider spacing maintenance in SRI and modified drumseeder in both row to row and plant to plant might have encouraged vigorous root system and the plants get sufficient space above the ground to grow and the increased light transmission in the canopy thus leading to greater plant height. Similar results were reported by [23], [24], [25], [8] and [26]. During both the years of experimentation, it was found that at all the stages, 50% RDN through inorganic+50% RDN through organic treatment recorded significantly higher plant height compared to other treatments, followed by 100% RDN through inorganic treatment and 75% RDN through inorganic+25% RDN through organic treatment. These findings are in accordance with [21] [15].

3.2. Leaf Area Index (LAI)

At all the stages LAI recorded was significantly higher in SRI followed by modified drum seeder over normal drumseeder and NTP during both the years (Table 2). The LAI recorded in modified drum seeder was significantly on par with SRI during kharif 2012-13, rabi 2011-12 and 2012-13. The mean percentage increases of LAI in SRI at 105 DAS was 48.01, 43.21, 37.70, 34.01% over NTP during kharif 2011, kharif 2012, rabi 2011-12, rabi 2012-13 respectively (Table 2). This might be due to planting in square geometry with wider spacing and single seedling which facilitated for better utilization of the resources to obtain maximum leaf area and more number of leaves. These results are in conformity with findings of [26], [27], [14] and [23].

Maximum LAI was observed with the treatment 50% RDN through inorganic+50% RDN through organic at 105 DAS during all the seasons of study. 100% RDN through organic registered lowest LAI at all the stages of crop growth. The treatment 50% RDN through inorganic+50% RDN through organic influenced the plant growth, tiller number and dry matter accumulation and thus manifested higher LAI. [15], [16], [27], [14] and [24] also expressed the similar opinion.

The interaction effect among planting methods and nutrient management practices on leaf area index was found significant at 45DAS during kharif 2011 and pooled kharif mean (Table 2a). The interaction was also significant at 75 DAS during kharif 2011, kharif 2012, kharif pooled mean (Table 2a), rabi 2011, rabi pooled mean at 75 DAS in both the years and in pooled means (Table 2b). The data on interaction revealed that at all these stages SRI in combination with 50% RDN through organic+50% RDN through inorganic source registered higher LAI as compared to all other establishment and nutrient management combinations.

3.3 Dry matter production (kg ha^{-1}):

Increases in dry matter production of rice was rather slow up to 45 DAS, there after it increased linearly up to 105 DAS and further, it continued to increase until maturity but it occurred at a diminishing rate in both the years of the study (Table 3).

At 45 DAS the numerically higher values were observed with SRI (1989.8, 2607, 2290.1 and 3126.5 g of total dry matter m^{-2} during 2013 and 2014, respectively) followed by modified drum seeder, over other treatments (Table 3). The similar trend was also observed at 75, 105 DAS and at harvest. Highest values of drymatter accumulation was observed at harvest with SRI which was 17.49, 23.57, 14.79 and 23.72%higher as compared to normal transplanting during 2011kharif, 2012 kharif, 2011-12 rabi and 2012-13 rabi. The higher dry matter production in SRI planting method was attributed to planting of young and single seedling at shallow depth in wider spacing and two direction cono-weeding which lead to taller plants, higher leaf area, LAI, better root growth, profuse and strong tillers with higher crop growth rate. The results obtained in this investigation are in conformity to the findings of [26] [25].

Among all the nutrient management treatments 50% RDN through inorganic+50% RDN through organic recorded significantly higher drymatter accumulation, followed by 100% inorganic treatment, over other treatments. At all the stages of crop growth lowest drymatter accumulation was observed with 100% organic treatment. At harvest 100% organic treatment recorded 16.05%, 9.49%, 13.03%, 9.59%, 11.23% and 12.55% lower drymatter accumulation as compared to 50% inorganic+50% organic in kharif2011, kharif 2012, rabi 2011-12 and 2012-13, in pooled mean kharif and in pooled mean rabi respectively. These findings were in conformity with the results of [16] and [15].

3.4. Number of tillers m^{-2}

The average number of tillers m^{-2} of rice increased linearly up to 90 DAS. Narrow spacing in normal drum seeder and normal transplanting, wider spacing in SRI and modified drum seeder as led to significant difference in number of tillers m^{-2}. But number of tillers m^{-2} recorded was significantly higher in SRI over modified drum seeder at 60 and90 DAS and of pooled means, respectively (Table 4). At all the growth stages NTP recorded significantly lower number of panicles m^{-2} as compared to other establishment methods. As compared to normal transplanting SRI practice gets the benefit of the early phyllochron stages (less than four leaves) having higher potential to quick recovery and to produce more tillers. If transplanting is done beyond the fourth phyllochron (after about 15 days), the first primary tiller does not emerge and all of the descendents of this tiller are lost. Similarly, if transplanting is further delayed by the length of another phyllochron, the second primary tiller and all its descendents are also forgone. Planting in square method with wider spacing resulted in profuse tillering under SRI cultivation and facilitated plants for better utilization of the resources. Similar findings have also been reported by [26], [8], [9], [25].

In both the years application of 50% RDN through inorganic source+50% RDN through organic source recorded significantly higher tiller number m^{-2} over other all nutrient management practices. Several researchers observed similar results. 50% inorganic fertilizer with 50% organic source improved the general soil environment, physicochemical and biological conditions thus favouring the increased and timely availability of macro and micro nutrients helped in profuse tillering.

3.5. 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 drum seeder(Table 5).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 results were in accordance with the findings of [28], [29].

The yield advantage due to SRI over conventional planting was mainly due to more number of tiller production per unit area 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 subplots 50% RDN through inorganic + 50% RDN through organicproved 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 [30], [31]. During all the seasons 100% organic treatment recorded lowest grain yield [32].

The interaction effect of planting methods and nutrient management practices on grain yield during all the seasons of study and in pooled means was found to be significant (Table 5a). During kharif 2011, kharif 2012, rabi 2011-12, 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.

3.6. 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 6). 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 [28] [29] [33].

During all the four seasons and in pooled means highest straw yield was observed with treatment 50% RDN through inorganic source + 50% RDN through organic source. The superiority of this treatment was because of adequate supply of nitrogen throughout crop growth period that led to higher dry matter production [31]. The lowest straw yield was found with treatment 100% organic during all the seasons [32].

4. CONCLUSIONS:

SRI registered superior growth characters and higher yield of rice over other establishment methods. Among nutrient management practices 50% inorganic+50% organic performed better in terms of growth and yield. A combination of SRI along with 50% inorganic+50% organic nutrient management practice recorded significantly superior growth characters and higher yield over rest of the treatments.

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Table 1. Plant height (cm) at different stages of crop growth as influenced by establishment methods and nutrient management practices								
	45 DAS		*75 DAS*		*105 DAS*		*At harvest*	
	Kharif	**Rabi**	**Kharif**	**Rabi**	**Kharif**	**Rabi**	**Kharif**	**Rabi**
MAIN PLOTS	**Pooled**	**Pool**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**
M1 (SRI)	37.75	40.90	76.58	82.68	93.49	100.61	101.60	106.30
M2 (Modified Drum Seeder)	34.10	36.10	69.22	70.83	87.00	91.59	90.50	95.50
M3 (Normal Drum seeder)	34.50	36.50	70.78	80.08	79.61	84.01	89.70	94.70
M4 (NTP)	32.00	32.50	60.57	66.09	74.36	80.73	83.10	89.50
S.Em±	0.40	0.80	1.88	0.97	1.62	1.59	2.30	2.20
CD (*P*=.05)	1.30	2.80	6.49	3.36	5.60	5.49	8.00	7.50
SUBPLOTS								
N1 (100% Inorg)	35.40	37.80	71.45	76.45	85.82	91.18	93.40	98.60
N2 (75% Inorg+25% org)	32.70	34.30	67.00	73.11	80.21	86.23	87.40	94.00
N3 (50% Inorg+50% org)	39.20	41.60	76.82	81.25	93.33	96.15	101.20	104.10
N4 (100%org)	30.90	32.40	61.87	68.86	75.11	83.38	82.90	89.20
S.Em±	0.80	1.00	1.34	1.33	1.68	1.69	1.90	2.00
CD (*P*=.05)	2.40	2.80	3.91	3.89	4.90	4.92	5.60	5.90
MEAN	34.60	36.50	69.28	74.92	83.62	89.23	91.20	96.50
INTERACTIONS								
Sub at same level of Main								
S.Em±	1.70	1.90	2.68	2.66	3.36	3.37	3.90	4.00
CD (*P*=.05)	NS	NS	NS	NS	NS	NS	NS	NS
Main at same level of Sub								
S.Em±	1.50	1.90	2.99	2.50	3.33	3.32	4.10	4.10
CD (*P*=.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 2 : LAI at different stages of crop growth as influenced by establishment methods and nutrient management practices

	45 DAS						*75 DAS*						*105 DAS*						*At harvest*					
	Kharif			**Rabi**			**Kharif**			**Rabi**			**Kharif**			**Rabi**			**Kharif**			**Rabi**		
MAIN PLOTS	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pool**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**
M1 (SRI)	1.44	1.63	1.54	1.73	2.00	1.86	4.31	3.91	4.11	4.72	5.14	4.93	5.98	5.70	5.84	6.61	7.04	6.82	5.35	5.30	5.32	5.86	6.32	6.09
M2 (Modified Drum Seeder)	1.30	1.45	1.37	1.47	1.60	1.54	3.38	3.25	3.31	3.62	4.17	3.90	5.51	5.15	5.33	6.05	6.47	6.26	4.72	4.94	4.83	5.59	5.91	5.75
M3 (Normal Drum seeder)	1.06	1.31	1.19	1.19	1.38	1.28	2.58	2.36	2.47	3.31	3.71	3.51	4.65	4.57	4.61	5.32	5.96	5.64	4.01	4.35	4.18	4.91	5.31	5.11
M4 (NTP)	0.84	1.15	1.00	1.07	1.19	1.13	2.21	2.24	2.22	2.69	3.00	2.85	4.04	3.98	4.01	4.80	5.25	5.02	3.59	3.72	3.65	4.44	4.87	4.65
S.Em±	0.03	0.03	0.02	0.05	0.06	0.04	0.07	0.07	0.06	0.13	0.15	0.11	0.18	0.13	0.12	0.18	0.21	0.15	0.15	0.16	0.05	0.18	0.20	0.14
CD (*P*=.05)	0.10	0.11	0.06	0.18	0.20	0.15	0.25	0.25	0.20	0.44	0.51	0.40	0.63	0.46	0.42	0.63	0.74	0.52	0.51	0.57	0.17	0.62	0.68	0.47
SUBPLOTS																								
N1 (100% Inorg)	1.33	1.53	1.43	1.48	1.64	1.56	3.28	3.11	3.19	3.84	4.24	4.04	5.26	5.19	5.23	5.88	6.40	6.14	4.62	4.90	4.76	5.38	5.79	5.58
N2 (75% Inorg+25% org)	1.00	1.25	1.13	1.25	1.44	1.34	2.84	2.63	2.74	3.34	3.75	3.55	4.82	4.62	4.72	5.45	6.01	5.73	4.17	4.32	4.24	4.87	5.41	5.14
N3 (50% Inorg+50% org)	1.52	1.70	1.61	1.63	1.88	1.75	3.98	3.71	3.84	4.22	4.71	4.47	5.71	5.48	5.59	6.40	6.82	6.61	5.10	5.18	5.14	5.91	6.15	6.03
N4 (100%org)	0.79	1.06	0.93	1.09	1.23	1.16	2.39	2.31	2.35	2.93	3.32	3.12	4.39	4.11	4.25	5.05	5.49	5.27	3.78	3.91	3.85	4.63	5.06	4.85
S.Em±	0.03	0.04	0.02	0.05	0.05	0.04	0.08	0.08	0.07	0.13	0.13	0.08	0.17	0.16	0.14	0.18	0.21	0.11	0.16	0.15	0.13	0.18	0.18	0.14
CD (*P*=.05)	0.08	0.12	0.06	0.13	0.14	0.11	0.23	0.24	0.19	0.37	0.37	0.23	0.49	0.46	0.40	0.53	0.60	0.32	0.48	0.45	0.39	0.53	0.53	0.42
MEAN	1.16	1.39	1.27	1.36	1.54	1.45	3.12	2.94	3.03	3.58	4.00	3.79	5.04	4.85	4.95	5.69	6.18	5.94	4.42	4.58	4.50	5.20	5.60	5.40
INTERACTIONS																								
Sub at same level of Main																								
S.Em±	0.06	0.08	0.04	0.09	0.10	0.07	0.16	0.16	0.13	0.25	0.25	0.15	0.34	0.31	0.27	0.36	0.41	0.22	0.33	0.31	0.27	0.36	0.36	0.29
CD (*P*=.05)	0.16	NS	0.12	NS	NS	NS	0.47	0.48	0.38	0.74	NS	0.45	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Main at same level of Sub																								
S.Em±	0.06	0.08	0.04	0.09	0.10	0.08	0.16	0.16	0.13	0.25	0.26	0.18	0.34	0.30	0.26	0.36	0.42	0.24	0.32	0.31	0.24	0.36	0.37	0.28
CD(*P*=.05)	0.17	NS	0.12	NS	NS	NS	0.47	0.49	0.39	0.78	NS	0.55	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3 : Dry matter accumulation (kg ha^{-1}) at different stages of crop growth as influenced by establishment methods and nutrient management practices

	45 DAS						75 DAS						105 DAS						At harvest					
	Kharif			Rabi			Kharif			Rabi			Kharif			Rabi			Kharif			Rabi		
MAIN PLOTS	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pool**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**
M1 (SRI)	1990	2607	2298	2290	3126	2708	4106	4647	4413	4490	5308	4899	6800	7736	7268	7081	8341	7711	9187	10161	9674	10082	11083	10582
M2 (Modified Drum Seeder)	1556	2252	1904	1667	2547	2107	3521	3754	3676	3597	4645	4121	6383	7173	6778	6619	7558	7089	8400	9565	8983	9203	10381	9792
M3 (Normal Drum seeder)	1761	1754	1758	2013	1861	1937	3232	3375	3284	3793	3967	3880	6265	6551	6408	6964	6683	6823	8104	8663	8383	9383	9477	9430
M4 (NTP)	1341	1481	1412	1669	1663	1667	2993	3050	3012	3325	3370	3348	6129	6053	6091	6148	6217	6182	7818	8223	8021	8783	8958	8870
S.Em±	66	48	50	52	61	45	86	86	71	64	109	51	130	163	114	148	169	52	212	259	189	190	267	136
C.D(*P*=.*05*)	229	167	174	180	214	157	297	297	247	223	378	177	451	564	395	512	583	181	732	895	653	656	922	471
SUBPLOTS																								
N1 (100% Inorg)	1706	2148	1927	2040	2460	2250	3664	3838	3681	4034.5	4498.8	4266.6	6580	7037	6808	7086	7381	7233	8719	9333	9026	9610	10191	9901
N2 (75% Inorg+25% org)	1540	1883	1711	1723	2073	1898	3302	3485	3404	3586	4103	3844	6311	6691	6501	6408	7022	6715	7991	8901	8446	8962	9713	9337
N3 (50% Inorg+50% org)	2113	2418	2265	2360	2871	2615	4007	4377	4203	4373	5037	4705	7033	7432	7232	7481	7913	7697	9285	9854	9570	10375	10695	10535
N4 (100%org)	1290	1647	1469	1516	1795	1655	2880	3125	3096	3213	3652	3432	5654	6354	6004	5837	6483	6160	7514	8524	8019	8503	9299	8901
S.Em±	35	65	37	77	61	51	94	97	52	154	111	105	185	192	127	162	190	106	176	213	145	339	232	188
C.D(*P*=.*05*)	103	191	107	225	177	149	274	283	151	449	325	306	541	561	371	473	555	311	514	621	422	990	676	550
MEAN	1662	2024	1843	1910	2300	2105	3463	3706	3596	3801	4322	4062	6394	6878	6636	6703	7200	6951	8377	9153	8765	9362	9975	9668
INTERACTIONS																								
Sub at same level of Main																								
S.Em±	70	131	73	154	122	102	188	194	103	307	223	210	371	384	254	324	380	213	352	425	289	678	463	377
CD (*P*=.*05*)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Main at same level of Sub																								
S.Em±	90	123	81	104	122	100	184	188	114	129	222	189	347	371	248	296	370	192	371	450	314	617	481	354
CD (*P*=.*05*)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4:Number of tillers m^{-2} at various growth stages as influenced by establishment methods and nutrient management practices

	60 DAS						*90 DAS*					
	Kharif			**Rabi**			**Kharif**			**Rabi**		
MAIN PLOTS	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pool**	**2011**	**2012**	**Pooled**	**2011**	**2012**	**Pooled**
M1 (SRI)	281.33	330.75	306.04	327.00	374.17	350.58	361.25	385.08	373.17	378.75	406.75	392.75
M2 (Modified Drum Seeder)	273.50	309.25	291.38	275.50	359.33	317.42	324.67	356.25	340.46	321.92	352.17	337.04
M3 (Normal Drum seeder)	184.00	247.50	215.75	198.33	245.25	221.79	282.50	307.50	295.00	290.83	310.00	300.42
M4 (NTP)	145.50	236.83	191.17	180.00	218.42	199.21	270.75	297.00	283.88	283.58	297.17	290.38
S.Em±	6.99	6.83	6.14	9.06	11.51	8.62	7.23	9.68	7.20	7.52	10.66	6.95
C.D. (*P*=.*05*)	24.19	23.63	21.23	31.34	39.84	29.84	25.00	33.49	24.93	26.02	36.87	24.06
SUBPLOTS												
N1 (100% Inorg)	246.50	291.83	269.17	270.75	312.17	291.46	334.08	350.25	342.17	340.25	361.42	350.83
N2 (75% Inorg+25% org)	193.83	268.25	231.04	227.25	271.92	249.58	284.25	319.25	301.75	297.17	319.75	308.46
N3 (50% Inorg+50% org)	283.50	317.00	300.25	300.08	347.67	323.88	368.83	377.08	372.96	377.08	401.50	389.29
N4 (100%org)	160.50	247.25	203.88	182.75	265.42	224.08	252.00	299.25	275.63	260.58	283.42	272.00
S.Em±	8.77	8.96	5.75	6.21	10.81	5.83	9.42	11.48	8.35	5.19	11.33	6.38
C.D. (*P*=.*05*)	25.59	26.14	16.77	18.12	31.55	17.02	27.51	33.50	24.38	15.14	33.06	18.63
MEAN	221.08	281.08	251.08	245.21	299.29	272.25	309.79	336.46	323.13	318.77	341.52	330.15
INTERACTIONS												
Sub at same level of Main												
S.Em±	17.53	17.91	11.49	12.42	21.62	11.66	18.85	22.95	16.70	10.37	22.65	12.77
CD (*P*=.*05*)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Main at same level of Sub												
S.Em±	16.72	16.95	11.69	14.06	21.98	13.28	17.85	22.11	16.16	11.72	22.33	13.06
CD (*P*=.*05*)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5: Grain yield (kg ha^{-1}) as influenced by establishment methods and nutrient management 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 5a: Interaction of crop establishment methods and nutrient management practices on grain yield (kg ha^{-1})

	Kharif 2011					Kharif 2012					Kharif pooled mean					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**	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	6534	6310	7090	5817	6438	7058	6646	7073	5801	6645	6796	6478	7081	5809	6541
M2- Modified drum seeder	5482	4942	5749	5249	5356	6643	6625	5872	583	6244	6053	5407	6196	5542	5799	6079	6018	6055	5283	5859	6363	6041	6603	6141	6287	6220	6029	6329	5711	6072
M3- Normal drum seeder	4753	5451	4910	5222	5084	6221	5929	5539	4851	5635	5341	5494	5565	5036	5359	5416	4953	5315	5882	5392	6433	5995	6023	5907	6090	5924	5474	5669	5894	5740
M4- NTP	4923	4714	5351	4787	4944	5695	5121	5375	5681	5468	5022	5044	5522	5233	5205	5562	5082	5670	5109	5356	5777	6128	6127	6069	6025	5669	5604	5898	5589	5690
MEAN	5363	5300	5693	5168		6383	6124	5827	5547		5743	5563	6038	5357		5898	5591	6033	5523		6408	6203	6457	5980		6152	5896	6244	5751	
	S.Em±		CD (P= .05)			S.Em ±		(P=. 05)			S.Em ±		CD at (P= .05)			S.Em ±		CD at (P= .05)			S.Em ±		CD at (P= .05)			S.Em±		CD at (P=. 05)		
Sub at same level of main	213		622			185		539			134		391			216		631			211		617			173		505		
Main at same level of sub	230		716			211		665			121		358			218		669			217		668			157		465		

Table 6: 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

Table 2a: Interaction of crop establishment methods and nutrient management practices on LAI

	at 45 DAS during kharif 2011					at 45 DAS in pooled kharif					at 75 DAS during kharif 2011					at 75 DAS during kharif 2012					at 75 DAS in pooled kharif				
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**	N_1	N_2	N_3	N_4	**MEAN**	N_1	N_2	N_3	N_4	**MEAN**
M1-SRI	1.74	1.10	1.96	0.98	1.44	2.03	1.80	1.24	1.09	1.54	4.65	3.84	5.86	2.90	4.31	4.34	3.39	5.21	2.71	3.91	5.54	4.50	3.62	2.81	4.11
M2- Modified drum seeder	1.45	1.24	1.65	0.84	1.30	1.72	1.50	1.25	1.03	1.37	3.45	3.17	4.06	2.84	3.38	3.30	2.98	4.01	2.70	3.25	4.04	3.38	3.08	2.77	3.31
M3- Normal drum seeder	1.23	0.96	1.36	0.70	1.06	1.44	1.33	1.14	0.84	1.19	2.65	2.39	3.24	2.04	2.58	2.42	2.09	2.96	1.98	2.36	3.10	2.54	2.24	2.01	2.47
M4- NTP	0.90	0.71	1.10	0.65	0.84	1.25	1.10	0.88	0.75	1.00	2.36	1.96	2.74	1.78	2.21	2.36	2.07	2.67	1.84	2.24	2.71	2.36	2.02	1.81	2.22
MEAN	1.33	1.00	1.52	0.79		1.61	1.43	1.13	0.93		3.28	2.84	3.98	2.39		3.11	2.63	3.71	2.31		3.84	3.19	2.74	2.35	
	S.Em±	CD at 5%				S.Em±	CD at 5%				S.Em ±	CD at 5%				S.Em ±	CD at 5%				S.Em±	CD at 5%			
Sub at same level of main	0.06	0.16				0.04	0.12				0.16	0.47				0.16	0.48				0.13	0.38			
Main at same level of sub	0.06	0.17				0.04	0.12				0.16	0.47				0.16	0.49				0.13	0.39			

Table 2b: Interaction of crop establishment methods and nutrient management practices on LAI

	75 DAS during rabi 2011-12					at 75 DAS in pooled rabi				
Establishment methods	N_1	N_2	N_3	N_4	**MEAN**	N_1	N_2	N_3	N_4	**MEAN**
M1-SRI	5.26	4.12	6.09	3.40	4.72	6.15	5.45	4.42	3.71	4.93
M2- Modified drum seeder	3.76	3.39	4.10	3.23	3.62	4.50	4.02	3.66	3.41	3.90
M3- Normal drum seeder	3.49	3.15	3.61	2.98	3.31	3.97	3.70	3.33	3.03	3.51
M4- NTP	2.86	2.70	3.09	2.12	2.69	3.26	3.00	2.78	2.35	2.85
MEAN	3.84	3.34	4.22	2.93		4.47	4.04	3.55	3.12	
	S.Em ±		CD at 5%			S.Em ±		CD at 5%		
Sub at same level of main	0.25		0.74			0.15		0.45		
Main at same level of sub	0.25		0.78			0.18		0.55		