International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 282-287

Received: 28-09-2019
Accepted: 30-10-2019

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Studies on physiological characteristic of rice (*Oryza sativa* L.) as influence by crop establishment methods and nitrogen management under lowland condition of Manipur valley

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Abstract
A field experiment was conducted during pre-*kharif* season of 2016 and 2017 at Research Farm, College of Agriculture, Central Agricultural University, Imphal, Manipur, to study the effect of crop establishment methods and nitrogen management practices on physiological characteristic of rice. The experiment was laid out in split plot design with three crop establishment methods in main plot and four nitrogen management practices assigned to sub plot with three replication. Among the crop establishment methods SRI method has highest dry matter production hill^{-1}, RGR while conventional method has highest LAI and ICM recorded the highest CGR and NAR. Treatment N3-75% RDN through urea + 25% RDN through FYM produces the highest value in all the physiological character and yield than the remaining three nitrogen management practices. However, due to more dry matter production per meter and crop growth rate ICM contributed the highest yield among the crop establishment methods.

Keywords: Rice, pre-*kharif*, CGR, RGR, NAR, yield

Introduction
Rice is the staple and dominant food crop of India which feed more than 60% of the population. It occupies about 23.3% of gross cropped area of the country. Rice contributes 43% of total food grain production and 46% of the total cereal production of the country (Directorate of rice, GOI). But the productivity of rice in India is lower (2.04 tonnes ha^{-1}) as compared to Japan (6.25 tonnes ha^{-1}), China (6.24 tonnes ha^{-1}), and Indonesia (4.25 tonnes ha^{-1}). India will need to produce 130 million tonnes of rice by 2030 compared with the present production of 102.75 million tonnes with less land area for the cultivation due to increase in population. Increasing the production of rice is possible only by increasing the area for rice production and raising the cropping intensity through proper management like optimum plant density and fertilizer used. The used of modern rice varieties with shorter duration also provide an option in increasing the cropping intensity by growing rice during pre-*kharif* season which majority of the share came from *kharif* season. In the state of Manipur also agriculture is the most dominant occupation which more than 52.19% of the working population directly depend for their livelihood (Economic survey of Manipur, 2016-17). Rice is the staple food and is grown in hill and plain areas and it account for about 95 percent of the total foodgrains production of the state in 2009-10. Growing rice during pre-*kharif* season is a challenging task as Manipur is dependent on monsoon rain for growing rice. But with proper irrigation with judicious used of water coming from river and aquifer we can successfully grow rice during pre-*kharif* also. With an option like maintaining optimum plant population and good nitrogen management practices we can grow rice in the place where limited source of water is present. This lead to indenting alternate methods of rice cultivation such as System of Rice Intensification (SRI), integrated crop management (ICM) etc. without compromising the yield. SRI and ICM have the potential to meet the increased rice demand and at the same time conserve natural resource base for posterity. Maintaining the optimum plant population is the pre-requisite for utilizing all the aerial and underground resources.
Application of fertilizer nitrogen is an essential input for increasing the crop productivity in rice. It is estimated that 24% increase in Asian rice was attributed to use of fertilizers, mainly nitrogen. Generally rice crops need a higher amount of N 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.

In rice production, efficient use of N fertilizer is a critical factor in achieving high and stable yield, while minimizing negative effects to the environment (Ntamatungiro *et al*., 1999, Hirel and Lemaire, 2005, Tylaran *et al*., 2009) [12, 9, 19]. Sahrawat, (1979) [16] reported that mineral N through inorganic fertilizer was more susceptible to different type of N losses and hence it has low N use efficiency as compared to organic materials. Integrated approaches of organic and inorganic nutrients management have shown an increased efficiency of applied N fertilizer in rice (Buresh and De Datta, 1991) [5]. This is because of minimal loss of N in case of organic sources and N was available to the crop for longer period and it is important for economic sustainability of cropping systems. Furthermore, the dynamic nature of N and its propensity for loss from soil-plant systems creates a unique and challenging environment for its efficient management (Fageria and Baligar, 2005) [8]. Integrated nutrient management of fertilizers Specially nitrogen and organic manures, therefore, is one of the viable options for sustaining soil health *vis-à-vis* crop productivity (Bajpai *et al*., 2006) [4]. Therefore the present investigation was conducted to study the effect of crop establishment methods and nitrogen management on physiological character of rice.

Materials and Methods

A field experiment entitled "Studies on physiological characteristic of rice (*Oryza sativa* L.) as influence by crop establishment methods and nitrogen management under lowland condition of Manipur valley'' was conducted in 2016 and 2017 during the pre-*kharif* season at the Research Farm, College of Agriculture, Central Agricultural University, Imphal. The experimental field was situated at 24051"N latitude and 93056"E longitude at an altitude of 790 meter above mean sea level. The soil of the experimental site was clay in nature with acidic in pH (5.4). Medium in available nitrogen (346.06 kg ha^{-1}), phosphorus (30.78 kg ha^{-1}), and potassium (248.12 kg ha^{-1}) but high in organic carbon (2.36%). The total annual rainfall for the year 2016 was 1850.9 mm and in 2017 it was 2439.4 mm.

The experimental field was properly level after ploughing by using leveler and plot are made according to the requirement (12 m^2) for conducting research. Land was divided into individual plots with proper arrangement of bunds and irrigation channel as per the lay out specifications. The experiment was laid out in split plot design keeping crop establishment in the main plot and nitrogen management in the sub-plot. The factor of experiment include three crop establishment methods *viz*. C1- SRI (25 x 25 cm^2), C2-ICM (20 x 20 cm^2), C3-conventional methods (20 x 10 cm^2) and four nitrogen management practices *viz*. N1-100% recommended dose of nitrogen (RDN) through urea, N2-100% RDN through farm yard manure (FYM), N3-75% RDN through urea + 25% RDN through FYM and N4-50% RDN through urea + 50% RDN through FYM replicated thrice. Same treatment was superimposed on the same plot for the second year also to study the cumulative effect of the treatment. A short duration rice variety CAUR-3 was used as test crop for the experiment. Healthy and disease free seed were selected for raising the seedling. After soaking the seed for 48 hour again mix with Carbendazim @ 2.5 g kg^{-1} seed and again tight in a gunny bag till it sprouted. The sprouted seed were taken in tray and sown in the nursery bed. Seed was sown on 19th February in both the year and transplant according to the required age of the crop establishment methods. In SRI one seedling were transplanted at the age of ten days, two seedlings at 15 days for ICM and three to four seedling at the age of twenty one days for conventional method. Gap filling was done after seven days to maintain the required plant population.

FYM was applied on the plot before ten days of transplanting according to the treatment. Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal. The remaining half dose of nitrogen was applied at maximum tillering and panicle initiation stage. Alternate drying and wetting was maintained in SRI and ICM and sufficient standing water was kept on conventional method. Five destructive plant samples were selected randomly from border area was uprooted at an interval of 30 days for estimating leaf area index (LAI), dry matter production $hill^{-1}$ (g $hill^{-1}$), crop growth rate (CGR), relative growth rate (RGR) and net assimilation ratio (NAR). After finding the LAI the samples are further shade dried again to take out the moisture and keep in the oven at 70 ˚C till it attains constant weight. The weights are recorded in g $hill^{-1}$. Leaf area index was estimated by using the formula by Watson, 1952 [21].

$$LAI = \frac{\text{Leaf area per plant (cm)}}{\text{Ground area (cm)}}$$

CGR was measured using the formula as suggested by Watson (1956) [22]:

$$CGR = \frac{W2 - W1}{P(T2 - T1)}$$

Where, W2 and W1 are the dry matter production at time T2 and T1, P is the ground area on which W2 and W1 are recorded and it is express in g m^{-2} day^{-1}.

RGR was measured by using the formula as suggested by Williams (1946)

$$RGR = \frac{\log_e W2 - \log_e W1}{T2 - T1}$$

Where, W2 and W1 are the dry matter production at time T2 and T1, Log_e (Natural log value) = 2.3 and it is express in (g $g^{-1}day^{-1}$).

NAR was measured by using the formula as suggested by William (1946)

$$NAR = \frac{(W2 - W1)}{(T2 - T1)} \times \frac{(\log_e L2 - \log_e L1)}{(L2 - L1)}$$

Where, W1and W2 is dry weight of whole plant at time T1 and T2 respectively, L1 and L2 are leaf area at T1 and T2 respectively, T1 and T2 are time interval in days and it is express in (g $g^{-1}day^{-1}$).

Two border rows were removed from the whole plot to harvest the net plot area and keep it separately for each plot. To separate the grain and straw threshing was done followed by winnowing.

The data generated from both the year was analyzed using analysis of variance (ANOVA) and the difference between treatment means was tested for their statistical significance with appropriate critical difference (CD) at 5 per cent level of probability (Gomez and Gomez, 1984). The treatment where there is no significant difference it is denoted by "NS".

Results and Discussion

Effect of crop establishment methods and nitrogen management on dry matter production $hill^{-1}$

From table 1 it was revealed that dry matter production (g $hill^{-1}$) increases from 30 DAT till harvest. At all the stages of crop

SRI recorded the highest dry matter production followed by ICM and conventional method respectively. Due to less population without much competition for aerial and ground resources SRI contributed the tallest plant and tiller hill^{-1} and thus lead to more dry matter production hill^{-1}. From the pooled data it was found that at harvest also C1-SRI (38.80 g hill^{-1}) produces the highest dry which was significantly higher over C2-ICM (25.81 g hill^{-1}) and C3-conventional method (11.18 g hill^{-1}). The results were in conformity with the finding of Islam *et al*. (2013) [10] and Wahlang *et al*. (2015) [20]. Difference in plant height, tiller hill^{-1} and number of leaf due to nitrogen management practices it also produces significantly different in dry matter production hill^{-1}. Among nitrogen management practices N3-75% RDN through Urea + 25% RDN through FYM (26.40 g hill^{-1}) produces the highest dry matter production hill^{-1} which was at par with N1-100% RDN through Urea (26.01 g hill^{-1}) but significantly higher over the N4-50% RDN through Urea + 50% RDN through FYM (24.53 g hill^{-1}) and N1-100% RDN through Urea (24.12 g hill^{-1}) at all the interval except 30 DAT. More dry matter production from N1-100% RDN through Urea during 30 DAT might be due to fast solubilizing action of the Urea which can supply nutrient at a faster rate than the remaining three treatments. The integrated application of 75% RDN through Urea + 25% RDN through FYM might be a suitable proportion for the soil of Manipur. Similar finding was also recorded by Rajnesh Tomar *et al*. (2018) [14]. There was interaction among the treatment during 30 DAT in both the year. However, no interaction was found during 60, 90 DAT and harvesting.

Table 1: Effect of crop establishment methods and nitrogen management on dry matter production (g hill^{-1}) during 30, 60, 90 DAT and harvest

Treatment	30 DAT			60 DAT			90 DAT			Harvesting		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Crop establishment												
C1	3.88	4.00	3.94	20.98	21.17	21.07	33.12	33.32	33.22	38.63	38.97	38.80
C2	2.69	2.76	2.73	13.54	13.68	13.61	21.94	22.08	22.01	25.72	25.89	25.81
C3	0.96	1.23	1.09	6.43	6.46	6.44	9.61	9.74	9.68	11.11	11.25	11.18
SE(d)±	0.15	0.17	0.13	0.83	0.86	0.66	0.91	0.80	0.82	0.80	0.88	0.75
CD(p=0.05)	0.40	0.48	0.37	2.31	2.38	1.84	2.54	2.23	2.28	2.22	2.43	2.07
Nitrogen management												
N1	3.10	3.31	3.20	14.44	14.74	14.59	21.97	22.09	22.03	25.93	26.09	26.01
N2	1.92	2.07	1.99	12.09	12.29	12.19	20.83	21.03	20.93	23.98	24.25	24.12
N3	2.89	3.07	2.98	15.65	15.51	15.58	22.17	22.33	22.25	26.32	26.47	26.40
N4	2.14	2.21	2.17	12.41	12.54	12.48	21.25	21.41	21.33	24.38	24.67	24.53
SE(d)±	0.10	0.12	0.07	0.80	0.72	0.47	0.61	0.69	0.50	0.73	0.74	0.48
CD(p=0.05)	0.20	0.26	0.16	1.68	1.51	0.98	NS	NS	NS	1.53	1.56	1.02
Interaction												
SE(d)± for NM on CE methods	0.17	0.21	0.13	1.38	1.24	0.81	1.06	1.20	0.86	1.26	1.28	0.84
CD(p=0.05) for NM on CE methods	0.35	0.45	0.27	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE(d)± for CE methods on NM	0.19	0.24	0.16	1.40	1.31	0.91	1.21	1.25	1.03	1.30	1.35	0.97
CD(p=0.05) for CE methods on NM	0.46	0.56	0.40	NS	NS	NS	NS	NS	NS	NS	NS	NS

Effect of crop establishment methods and nitrogen management on leaf area index

Leaf area index increases gradually from 30 DAT to 90 DAT and started decline during harvesting stage due to senescence of leaf during harvest stage Lampayan *et al*. (2010) [11]. Among crop establishment methods conventional methods recorded the highest lead area index during the entire interval from 30 DAT to harvest. Closer spacing has more leaf per unit area which might have contributed higher leaf area index than wider spacing; it was in close conformity with the finding with of Archana Rajput *et al*. (2017) [1]. The rate of increase was highest during 60 DAT but gradually decrease. Highest leaf area index was recorded from N3-75% RDN through Urea + 25% RDN through FYM followed by N1-100% RDN through Urea, N3-50% RDN through Urea + 50% RDN through FYM and N2-100% RDN through FYM. At 30 DAT treatment N1-100% urea contributed the highest LAI which might be due to availability of more nutrient from chemical fertilizer as chemical fertilizer are readily available source of nutrient to plant. But during 60 DAT, 90 DAT and at harvest treatment N3-75% RDN through urea + 25% RDN through FYM recorded the highest value of LAI.

Table 2: Effect of crop establishment methods and nitrogen management on leaf area index (LAI) during 30, 60, 90 DAT and harvest.

Treatment	30 DAT			60 DAT			90 DAT			Harvesting		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Crop establishment												
C1	0.83	0.86	0.85	3.08	3.60	3.34	4.75	5.11	4.93	1.13	1.14	1.13
C2	0.89	0.92	0.90	3.59	3.86	3.72	5.10	5.29	5.19	1.24	1.28	1.26
C3	0.94	1.02	0.98	4.36	4.59	4.48	6.55	6.64	6.60	1.57	1.62	1.59
SE(d)±	0.07	0.05	0.05	0.24	0.33	0.15	0.40	0.30	0.23	0.08	0.08	0.06
CD(p=0.05)	NS	0.13	NS	0.66	NS	0.43	1.12	0.84	0.65	0.23	0.24	0.18
Nitrogen management												
N1	1.08	1.10	1.09	3.60	4.07	3.83	5.53	5.76	5.65	1.36	1.42	1.39
N2	0.73	0.77	0.75	3.37	3.56	3.46	4.94	5.06	5.00	1.04	1.11	1.08
N3	0.90	0.97	0.93	4.23	4.50	4.37	6.09	6.50	6.30	1.55	1.55	1.55
N4	0.84	0.89	0.87	3.51	3.92	3.72	5.30	5.40	5.35	1.29	1.30	1.30
SE(d)±	0.07	0.04	0.04	0.17	0.23	0.13	0.32	0.21	0.23	0.05	0.08	0.04
CD(p=0.05)	0.14	0.08	0.09	0.36	0.47	0.27	0.67	0.45	0.48	0.11	0.17	0.09

Interaction												
SE(d)± for NM on CE methods	0.12	0.06	0.07	0.30	0.39	0.23	0.56	0.37	0.39	0.09	0.14	0.07
CD(p=0.05) for NM on CE methods	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE(d)± for CE methods on NM	0.12	0.07	0.08	0.33	0.44	0.24	0.60	0.41	0.40	0.11	0.14	0.08
CD(p=0.05) for CE methods on NM	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Effect of crop establishment methods and nitrogen management on crop growth rate (CGR) of rice

Crop growth rate decrease from 30-60 DAT till 90 DAT-harvest which might be due to difference in magnitude during development of dry matter production at all the interval. Crop establishment methods influence the CGR at all the interval but there was no significant difference at all the interval of crop growth. The highest value of CGR was obtained at ICM at all the interval which was followed by SRI and conventional method which might be due to proper utilization of all the resources with optimum plant density. From the pooled data there was significance difference during 30-60 DAT and 60-90 DAT but no significance difference during 90 DAT-harvest. During the entire interval N3 produces the highest value of CGR followed by N1, N4 and N2. Nutrient supplied in the proportion 75% RDN through Urea + 25% RDN through FYM might be a suitable combination with synchronize supply of nutrient from inorganic and organic sources in the context of Manipur soil.

Table 3: Effect of crop establishment methods and nitrogen management on Crop Growth Rate (CGR) during 30-60, 60-90 and 90 DAT-harvest (g $m^{-2}day^{-1}$)

Treatment	30-60 DAT			60-90 DAT			90 DAT-Harvest		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Crop establishment									
C1	9.11	9.12	9.12	6.47	6.51	6.49	2.94	3.01	2.98
C2	9.12	9.16	9.14	7.00	7.04	7.02	3.15	3.24	3.19
C3	9.04	9.10	9.07	5.31	5.50	5.40	2.51	2.83	2.67
SE(d)±	1.04	0.59	0.71	1.26	0.93	0.78	0.90	1.07	0.97
CD(p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen management									
N1	9.28	9.29	9.29	6.79	6.81	6.80	3.21	3.33	3.27
N2	8.18	8.20	8.19	5.14	5.30	5.22	2.41	2.62	2.51
N3	10.50	10.58	10.54	7.11	7.24	7.18	3.37	3.38	3.37
N4	8.39	8.42	8.41	6.00	6.04	6.02	2.48	2.78	2.63
SE(d)±	0.59	0.55	0.40	0.70	0.80	0.46	0.84	0.77	0.52
CD(p=0.05)	1.23	1.16	0.84	1.47	NS	0.98	NS	NS	NS
Interaction									
SE(d)± for NM on CE methods	1.02	0.95	0.69	1.21	1.39	0.80	1.45	1.34	0.91
CD(p=0.05) for NM on CE methods	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE(d)± for CE methods on NM	1.26	0.97	0.85	1.51	1.45	0.97	1.48	1.48	1.15
CD(p=0.05) for CE methods on NM	NS	NS	NS	NS	NS	NS	NS	NS	NS

Effect of crop establishment methods and nitrogen management on relative growth rate of rice

RGR found to decrease from 30-60 DAT till 90 DAT-harvest which might be due to shedding of leaves due to senescence. These results are in agreement with those obtained by Azarpour *et al*. (2014) [33]. There was no significance difference for RGR among the crop establishment methods at all the interval of crop growth. From the pooled data it was found out that nitrogen management has significance difference during 30-60 DAT and 60-90 DAT but not during 90 DAT-harvest. Dry weight increase from unit dry weight is more in treatment N3 which might be due to favorable combination of 75% RDN through Urea + 25% RDN through FYM in supplying nutrient.

Table 4: Effect of crop establishment methods and nitrogen management on relative growth rate (RGR) during 30-60, 60-90 and 90 DAT-harvest (g g^{-1} day^{-1})

Treatment	30-60 DAT			60-90 DAT			90 DAT-Harvest		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Crop establishment									
C1	0.056	0.063	0.059	0.016	0.016	0.016	0.005	0.005	0.005
C2	0.056	0.057	0.056	0.015	0.016	0.016	0.005	0.005	0.005
C3	0.054	0.054	0.054	0.014	0.014	0.014	0.005	0.005	0.005
SE(d)±	0.002	0.004	0.002	0.002	0.003	0.002	0.001	0.001	0.001
CD(p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen management									
N1	0.058	0.059	0.059	0.017	0.018	0.018	0.005	0.006	0.006
N2	0.049	0.053	0.051	0.012	0.011	0.011	0.005	0.005	0.005
N3	0.059	0.063	0.061	0.018	0.019	0.019	0.006	0.006	0.006
N4	0.054	0.057	0.055	0.014	0.014	0.014	0.005	0.005	0.005
SE(d)±	0.059	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001
CD(p=0.05)	0.005	0.006	0.004	0.005	0.004	0.003	NS	NS	NS
Interaction									
SE(d)± for NM on CE methods	0.004	0.005	0.003	0.004	0.003	0.003	0.002	0.003	0.002

CD(p=0.05) for NM on CE methods	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE(d)± for CE methods on NM	0.004	0.006	0.004	0.004	0.004	0.003	0.003	0.003	0.002
CD(p=0.05) for CE methods on NM	NS	NS	NS	NS	NS	NS	NS	NS	NS

Effect of crop establishment methods and nitrogen management on net assimilation rate (NAR) of rice

Net assimilation rate decrease during later stage due to shedding of leaves which hinder solar radiation absorbed by the leaves therefore less photosynthetic assimilates produced which causes lowering the net assimilation rate. From the pooled data it was found out that there was significance difference during 30-60 DAT but no significance difference during 60-90 DAT among crop establishment methods. ICM contributed the highest value of NAR followed by SRI and conventional method. This result was in conformity with the finding of Paul *et al*. (2016) [13] and Salem *et al.* (2011) [17]. Due to nitrogen management there was no significance difference during 30-60 DAT but there was significance difference during 60-90 DAT. Among nitrogen management N3-75% RDN through Urea + 25% RDN through FYM followed by N1-100% RDN through Urea, N4-50% RDN through Urea + 50% RDN through FYM and N2-100% RDN through FYM.

Table 5: Effect of crop establishment methods and nitrogen management on net assimilation rate (NAR) during 30-60 and 60-90 DAT (g m^{-2} day^{-1})

Treatment	30-60 DAT			60-90 DAT		
	2016	2017	Pooled	2016	2017	Pooled
Crop establishment						
C1	4.48	4.88	4.68	1.55	1.63	1.59
C2	4.80	5.38	5.09	1.60	1.68	1.64
C3	3.72	4.06	3.89	1.00	0.99	1.00
SE(d)±	0.32	0.46	0.26	0.28	0.30	0.22
CD(p=0.05)	0.88	NS	0.73	NS	NS	NS
Nitrogen management						
N1	4.49	4.84	4.67	1.56	1.59	1.58
N2	4.00	4.60	4.30	1.00	1.12	1.06
N3	4.61	5.08	4.85	1.70	1.69	1.70
N4	4.22	4.55	4.39	1.27	1.34	1.30
SE(d)±	0.23	0.38	0.22	0.18	0.17	0.12
CD(p=0.05)	NS	NS	NS	0.39	0.35	0.25
Interaction						
SE(d)± for NM on CE methods	0.39	0.65	0.38	0.32	0.29	0.21
CD(p=0.05) for NM on CE methods	NS	NS	NS	NS	NS	NS
SE(d)± for CE methods on NM	0.44	0.69	0.40	0.37	0.36	0.26
CD(p=0.05) for CE methods on NM	NS	NS	NS	NS	NS	NS

Effect of crop establishment methods and nitrogen management on grain yield (t ha^{-1}) and straw yield (t ha^{-1})

From the pooled data of grain yield ICM (4.97 t ha^{-1}) produces the highest grain yield which was at par with SRI (4.73 t ha^{-1}) but significantly superior over conventional method (3.56 t ha^{-1}). ICM was 4.82% and 28.32% higher over SRI and conventional method in grain yield production (table 6). The reason for producing more grain yield in ICM might be due to production of more dry matter production $meter^{-2}$, optimum LAI, more crop growth rate and net assimilation rate with more effective tiller $meter^{-2}$ and number of filled grain similar finding was recorded from Thakur *et al*. (2009) and Avasthe *et al*. (2012) [2]. Conventional method with closer spacing produces high value of LAI which might lead to bending and lodging of crop which reduces the grain yield as well as straw yield. The highest straw yield was also obtained from ICM which was comparable with SRI but significantly higher over conventional methods which might be due to more dry matter accumulation $meter^{-2}$.

Table 6: Effect of crop establishment methods and nitrogen management on grain yield (t ha^{-1}), straw yield (t ha^{-1})

Treatment	Straw yield			Grain yield		
	2016	2017	Pooled	2016	2017	Pooled
Crop establishment						
C1	6.18	6.29	6.23	4.67	4.80	4.73
C2	6.43	6.52	6.48	4.91	5.02	4.97
C3	5.56	5.62	5.59	3.51	3.61	3.56
SE(d)±	0.22	0.21	0.20	0.25	0.25	0.20
CD(p=0.05)	0.61	0.59	0.56	0.69	0.69	0.56
Nitrogen management						
N1	6.27	6.31	6.29	4.43	4.52	4.47
N2	5.73	5.79	5.76	3.93	4.01	3.97
N3	6.38	6.55	6.46	5.03	5.23	5.13
N4	5.85	5.92	5.89	4.07	4.15	4.11
SE(d)±	0.21	0.19	0.14	0.17	0.16	0.14
CD(p=0.05)	0.45	0.39	0.28	0.36	0.34	0.30
Interaction						
SE(d)± for NM on CE methods	0.37	0.32	0.23	0.30	0.28	0.25

CD(p=0.05) for NM on CE methods	NS	NS	NS	NS	NS	NS
SE(d)± CE methods on NM	0.37	0.33	0.27	0.34	0.32	0.28
CD(p=0.05) for CE methods on NM	NS	NS	NS	NS	NS	NS

Nitrogen management also has significant difference on grain yield and straw yield. Plot with treatment N3-75% RDN through urea + 25% RDN through FYM (table 6) produce highest grain and straw yield. There was a difference of 12.86% in grain yield from N3-75% RDN through urea + 25% RDN through FYM over N1-100% RDN through Urea, 19.88% and 22.61% more grain yield over N4-50% RDN through Urea + 50% N through FYM and N2-100 RDN through FYM. This might be due to favorable soil condition and synchronized release of nutrient from the source which gives optimum LAI, more dry matter accumulation, more CGR, more NAR, more effective tiller meter^{-2}, and filled grain. Similar finding was also observed from Reddy *et al*. (2004) [15].

Acknowledgement
The authors would like to appreciate and acknowledge the authorities of College of Agriculture, Central Agricultural University, Manipur for providing field and support for making the Ph.D. research successful.

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