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Effect of crop establishment, nitrogen levels and time of nitrogen application on growth and yield attributing parameters of direct seeded rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted during 2016 and 2017 at the Agricultural Research Farm, Banaras Hindu University, Varanasi (U.P.) India. Field experiments were laid out in split plot design replicated thrice. The soil of the experimental field was sandy clay loam texture with pH 7.3. It was moderately fertile, being low in available organic carbon (0.34 %), available nitrogen (214.60 kg ha^{-1}) and medium in available phosphorus (18.45 kg ha^{-1}) and potassium (220.69 kg ha^{-1}). The experiment was laid out in split-plot design with two crop establishment methods viz., C_1- Conventional tillage, C_2-Zero tillage and four nitrogen levels viz. N_1- 90 kg ha-1, N_2- 120 kg ha^{-1}, N_3- 150 kg ha^{-1} and N_4- 180 kg ha^{-1} in the main plot and four time of nitrogen application treatment viz. T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading in sub-plots for both the years. Zero till DSR has recorded higher in growth, yield and yield contributing parameters compared to the conventional DSR. Among nitrogen levels, 180 kg N ha $^{-1}$ recorded significantly higher growth which is identical with application of 150 kg N ha $^{-1}$, However, in case of yield and yield contributing parameters significantly higher yield was observed with 150 kg N ha $^{-1}$ which is at par with 180 kg N ha $^{-1}$. Treatment (T_3) 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation were significantly influenced growth, yield and yield attributes such as plant height, number of tillers m^{-2}, dry matter accumulation and LAI, panicle weight, panicle m^{-2}, grains per panicle, fertility percentage grain yield and straw yield respectively as compared to rest of the treatments except treatment (T_2) 15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage. During both the years of experimentation.

Keywords: Crop establishment methods, Nitrogen levels, Time of nitrogen application and direct seeded rice

Introduction
Rice (*Oryza sativa* L.) is the staple food of more than 60 per cent of world population, which is grown in 112 countries covering every continent and it is consumed by 2500 million people in developing countries, mostly in Asia (90%) and rest (10%) in America, Africa, Australia and Europe. Direct seeded rice has many notable benefits such as more efficient water use, high tolerance to water scarcity, less methane emission, reduced cultivation cost, prevents the formation of hard pan crust in sub-soil and reduced laborer input. Zero till DSR (ZT DSR) with residue was found to be most effective in minimizing weed density, dry weight and nutrient depletion by weeds and enhancing crop growth, yield attributes, grain yield and NPK uptake for longer duration (Singh *et al.*, 2014). Due to more cost of labour and higher water use in puddling for transplanting rice in the irrigated eco-systems, direct seeding of rice is gaining popularity in south-east Asia (Balasubramanian and Hill, 2002) [2]. Direct-seeded rice needs only 34% of the total labour requirement and saves 29% of total cost of the transplanted crop. Application of 150 kg N ha^{-1} registered significantly higher number of tillers, panicles, grains/panicle, 1000-grain weight and grain yield than 100 kg N ha^{-1} Ramesh *et al.* (2009) [13]. Appropriate crop establishment option for DSR with efficient nitrogen management may play a vital role in improving nitrogen use efficiency, weed management and enhancing productivity and profitability in rice.

Material and Methods

The soil of the experimental field was sandy clay loam texture with pH 7.3. It was moderately fertile, being low in available organic carbon (0.34 %), available nitrogen (214.60 kg ha^{-1}) and medium in available phosphorus (18.45 kg ha^{-1}) and potassium (220.69 kg ha^{-1}). The experiment was laid out in split-plot design with two crop establishment methods viz., C_1- Conventional tillage, C_2-Zero tillage and four nitrogen levels viz. N_1- 90 kg ha^{-1}, N_2- 120 kg ha^{-1}, N_3- 150 kg ha^{-1} and N_4- 180 kg ha^{-1} in the main plot and four time of nitrogen application treatment viz. T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading in sub-plots for both the years. Thereafter, all thirty two treatment combinations were replicated thrice. A uniform dose of 60 kg P_2O_5 and 60 kg K_2O ha^{-1} was applied to all treatments. Nitrogen was applied as per the treatment and at particular growth stage i.e. basal application, at active tillering, at panicle initiation and at heading stage. Sources of N, P and K were urea, single super phosphate and muriate of potash, respectively. Rice variety "Sarjoo 52" was sown at the rate of 30 kg ha^{-1} during the last week of June at 20 cm row spacing with zero seed drill machine. The required quantity of pre-emergence and post-emergence herbicides were applied to control weeds with proper spray volume ha^{-1} using knap sack sprayer.

Results and Discussion

Effect on growth characters

The findings of the present study showed that crop establishment methods had influenced growth characters of crop such as Initial plant population at 20 DAS, plant height, number of tillers and dry matter accumulation significantly higher in zero till DSR than that of conventional DSR at harvest Initial Plant population was not affected due to crop establishment methods during both years. This might be due to fact that seed was properly placed in soil in both the methods of crop establishment under appropriate soil moisture and at proper depth as germination largely depends upon the energy stored in seeds. In the present study pure quality certified seed were sown which resulted in to uniform germination.

The findings of the present study showed that growth characters of crop such as plant height, number of tillers m^{-2} and Dry matter accumulation were significantly higher in zero till DSR than that of conventional DSR which may be due to minimum weed infection under zero till DSR, which promotes crop growth., Similar or high growth characters in ZT DSR than CT DSR were reported earlier by many researchers [Shad and De Datta (1986) [15], Hobbs *et al*. (2002) [5] and Yadav *et al*. (2014)].

Among the nitrogen levels, application of 180 kg N ha^{-1} resulted in higher growth characters which was followed by application of 150 kg N ha^{-1} during both the years of experimentation. This might be due to fact that with increasing in nitrogen levels there is positive increment in the plant height, which might have resulted more cell elongation and cell division in meristematic tissue of plant which play a key role in increasing plant height. Highest number of tillers m^{-2} might be due to higher nitrogen availability to crop concomitantly increased nutrient uptake. More plant height and number of till are positively increased with the dry matter and leaf area index. Better root and shoot development due higher nutrient application leads to better leaf area index. Higher numbers of tiller m^{-2} and leaf area index at higher nitrogen application resulted in increased dry matter accumulation at similar growth stages during both the years of experimentation. These finding are in conformity with Sharma (2007) [17] and Singh and Tripathi (2015) [19].

The significantly maximum plant height, number of tillers m^{-2}, dry matter accumulation and LAI were recorded with time of nitrogen application i.e. 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage which is at par with the treatment 15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage might be due to continuous nutrient available concomitant with crop growth stage. Nitrogen was applied as per need of crop in different split, so the chances of nitrogen losses through weed, leaching, volatilization and denitrification might be negligible in these treatment. Delaying or reducing basal dose of nitrogen does not affect crop growth as plant does not need much nitrogen during establishment and can be fulfilled this requirement by available nitrogen in soil. Applying nitrogen by 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage ascribed to the adequate supply of nutrients for better growth and development synchronized with crop demand. Split application of nitrogen, when synchronized with plant demand, has been reported as the best method to reduce nitrogen losses in direct seeded rice (lampayan *et al*., 2010) [9]. This result is in full agreement with the results reported earlier by Raj *et al*. (2014) [12] and Chaudhary *et al*., (2011) [4].

Nitrogen application of 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage and 25% N at 15-20 DAS + 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading recorded lower values in respect to all growth characters. This might be due to fact that in this treatment nitrogen was applied within one month including basal application which led to heavy weed infestation and more nitrogen losses in the treatment. The similar results were given by Rehman *et al*. (2013) [14]. The treatment which received heavy dressing of N at early growth stages registered lower growth attributes because of greater loss of N as denitrification and volatilization, which resulted in the deficiency of N at important crop growth stages which accelerated senescence of lower leaves, death of tillers and narrow and short leaves as reported by De Datta (1981).

Effect on yield and yield attributes

The findings of the present study showed that yield attributes *viz.* panicle length, grains per panicle, 1000 grain weight and number of panicle m^{-2} did not differed significantly due to crop establishment methods of rice during both the years of experimentation. However, zero till direct seeded rice recorded higher yield attributes compared to conventional DSR during both the years. This might to be due to zero tillage which would have helped in regulating the soil temperature and moisture, better supply of plant nutrients. Similar or high yield attributes and yield in ZT DSR than conventional DSR were reported earlier by many researchers [Choudhury *et al*. (2007) and Jat *et al*. (2009)].

Among the nitrogen levels, application of 180 kg N ha^{-1} recorded significantly higher panicle length, grains $panicle^{-1}$, number of panicles m^{-2} which is at par with application of 150 kg N ha^{-1}. Increased yield attributes with higher nitrogen

application might be due to better growth characters which ultimately resulted in higher production and translocation of photosynthates towards panicle. Higher nutrition to crop leads to better leaf area index development which provided more photosynthetic organs and more photo assimilates to be accumulated in economic part of crop. These results are in conformity with Mallhareddy and Padmaja (2013) [11]. Application of nitrogen by 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage resulted higher yield attributes which were however, at par with the treatment 15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage than other treatments. It might be due the resultant of higher leaf area index and dry matter production followed by more partitioning of photosynthates from source to sink and also due to lower weed infestation. Similar findings were reported by Bayan and Kandasamy (2002) [3] and Singh *et al*. (2015) [19].

Grain and straw yield

The findings of the present study showed that grain yield, straw yield and harvest index did not differed significantly due to crop establishment methods of rice during both the years of experimentation. However, in zero till DSR recorded higher grain yield, straw yield and harvest index compared to conventional DSR during both the years. This might to be due to zero till DSR recorded higher growth and yield attributes which would have facilitate better conversion of photosynthates to yield. Similar results were reported by Singh (2015) [19]. About Nitrogen levels, application of 150 kg N ha^{-1} followed by 180 kg N ha^{-1} recorded higher grain yield and reverse trend was observed in case of straw yield. It may be due to the fact that higher level of nitrogen may result in prosperous growth and which ultimately contributed in to the higher biomass accumulation and improve the straw yield to the level of significance. In case of grain yield, it is higher with application of 150 Kg N ha^{-1} as fertility percentage is higher as compared to 180 kg N h^{-1}. Ratio of conversion of photosynthates to grain yield is comparatively less with application of 180 kg N ha $^{-1}$ these results are in conformity with Mallhareddy and Padmaja (2013) [11]. Time of nitrogen application by 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage recorded higher grain and straw yield which were at par with the treatment 15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage (Tables 4.14). This might be due to improvement in the yield attributes like number of panicle bearing tillers, number of grains per panicle, panicle length Ali *et al.*, (2007).

Table 1: Effect of crop establishment methods, nitrogen levels and time of nitrogen application on initial plan population, plant height (cm), no of tillers m^{-2} and Dry matter (g / 0.25 m row length) at harvest on direct seeded rice during kharif 2016 and 2017.

Treatments	Initial plant population		Plant height (cm)		No of Tillers m^2			Dry matter (g / 0.25 m row length)
	2016	2017	2016	2017	2016	2017	2016	2017
Main Plot								
Crop Establishment Methods								
C_1: Conventional DSR	14.74	12.11	78.58	74.70	278.66	267.85	44.70	42.04
C_2: Zero till DSR	15.76	12.66	82.03	77.97	292.04	280.55	46.85	44.07
SEm±	0.62	0.62	1.04	1.00	4.25	2.99	0.97	0.77
LSD (*P*=0.05)	NS	NS	3.15	3.02	12.91	9.08	NS	NS
Nitrogen Levels (kg ha^{-1})								
N_1: 90 kg N ha^{-1}	13.51	10.34	74.27	67.85	243.73	236.48	37.41	34.54
N_2: 120 kg N ha^{-1}	12.72	10.85	77.51	73.35	280.02	262.68	43.44	40.64
N_3: 150 kg N ha^{-1}	17.01	13.97	82.97	80.47	300.38	289.47	49.61	46.42
N_4: 180 kg N ha^{-1}	17.76	14.38	86.48	83.68	315.27	308.17	50.63	48.62
SEm±	0.87	0.88	1.47	1.41	6.01	4.23	1.38	1.10
LSD (*P*=0.05)	2.65	2.66	4.46	4.27	18.23	12.84	4.18	3.32
Sub-Plot								
Time of Nitrogen Application								
T_1	16.29	14.40	79.63	74.33	275.16	265.11	43.58	41.55
T_2	15.04	12.73	80.80	77.75	286.66	275.91	46.17	44.03
T_3	14.83	10.65	87.18	85.70	298.83	285.73	48.93	45.52
T_4	14.83	11.75	73.61	67.56	278.76	270.05	42.41	39.12
SEm±	0.96	1.03	1.46	1.47	4.35	4.48	0.99	0.95
LSD (*P*=0.05)	NS	NS	4.14	4.18	12.36	12.75	2.83	2.70
Interaction								
C x N	NS	NS	NS	NS	NS	NS	NS	NS
C x T	NS	NS	NS	NS	NS	NS	NS	NS
N x T	NS	NS	NS	NS	S	S	S	S
C x N x T	NS	NS	NS	NS	NS	NS	NS	NS

T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS + 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading.

Table 2: Effect of crop establishment methods, nitrogen levels and time of nitrogen application on 1000-grain weight (g), Panicle length (cm), number of grains panicle^{-1} and Panicles m^{-2} of direct seeded rice during kharif 2016 and 2017.

Treatments	1000-grain wt (g)		Panicle length (cm)			Grains panicle^{-1}		Panicles m^{-2}
	2016	2017	2016	2017	2016	2017	2016	2017
Main Plot								
Crop Establishment Methods								
C_1: Conventional DSR	23.91	24.36	23.95	23.84	124.08	122.39	214.95	214.84
C_2: Zero till DSR	24.00	24.42	23.88	23.83	126.33	124.79	217.11	216.22
SEm±	0.09	0.04	0.04	0.06	1.29	1.61	1.64	1.12
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen Levels (kg ha^{-1})								
N_1: 90 kg N ha^{-1}	23.73	24.33	23.63	23.52	116.58	114.08	192.64	194.57
N_2: 120 kg N ha^{-1}	23.92	24.39	23.92	23.88	125.17	123.01	214.69	215.96
N_3: 150 kg N ha^{-1}	24.09	24.43	24.05	23.96	129.13	128.33	226.62	224.53
N_4: 180 kg N ha^{-1}	24.07	24.42	24.07	23.98	129.94	128.96	230.17	227.06
SEm±	0.13	0.05	0.06	0.09	1.82	2.27	2.33	1.58
LSD (*P*=0.05)	NS	NS	0.17	0.26	5.53	6.89	7.05	4.80
Sub-Plot								
Time of Nitrogen Application								
T_1	23.92	24.38	23.90	23.79	125.08	123.32	212.13	210.47
T_2	23.98	24.40	23.91	23.84	126.92	125.50	219.75	220.39
T_3	24.00	24.42	23.98	23.88	127.71	126.54	221.61	221.14
T_4	23.90	24.37	23.88	23.84	121.13	119.02	209.09	209.65
SEm±	0.09	0.07	0.07	0.09	1.48	1.84	2.82	2.55
LSD (*P*=0.05)	NS	NS	NS	NS	4.22	5.23	8.03	7.25
Interaction								
C x N	NS	NS	NS	NS	NS	NS	NS	NS
C x T	NS	NS	NS	NS	NS	NS	NS	NS
N x T	NS	NS	NS	NS	NS	NS	S	S
C x N x T	NS	NS	NS	NS	NS	NS	NS	NS

T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS + 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading.

Table 3: Effect of crop establishment methods, nitrogen levels and time of nitrogen application on grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%) of direct seeded rice

Treatments	Grain Yield (kg ha^{-1})			Straw Yield (kg ha $^{-1}$)		HI (%)
	2016	2017	2016	2017	2016	2017
Main Plot						
Crop Establishment Methods						
C_1: Conventional DSR	3924.44	3839.79	5462.44	5291.78	41.58	41.93
C_2: Zero till DSR	4075.56	3978.96	5722.56	5506.58	41.84	41.96
SEm±	67.91	65.87	103.83	80.54	0.35	0.37
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen Levels (kg ha^{-1})						
N_1: 90 kg N ha^{-1}	3234.46	3158.41	4552.71	4405.52	41.44	41.60
N_2: 120 kg N ha^{-1}	3901.88	3735.80	5492.13	5307.67	41.58	41.29
N_3: 150 kg N ha^{-1}	4335.21	4307.72	6018.46	5827.57	41.99	42.15
N_4: 180 kg N ha^{-1}	4328.46	4285.57	6306.71	6055.97	40.55	41.43
SEm±	96.04	93.16	116.02	113.90	0.50	0.56
LSD (*P*=0.05)	291.32	282.56	351.91	345.47	NS	NS
Sub-Plot						
Time of Nitrogen Application						
T_1	3775.88	3658.59	5437.88	5264.23	41.07	40.93
T_2	4076.71	4031.72	5718.71	5504.56	41.60	42.23
T_3	4260.38	4198.21	5884.38	5744.07	42.11	42.23
T_4	3687.04	3548.98	5329.04	5083.86	40.78	41.07
SEm±	72.01	77.13	113.79	97.29	0.43	0.44
LSD (*P*=0.05)	204.76	219.31	323.55	276.64	NS	NS
Interaction						
C x N	NS	NS	NS	NS	NS	NS
C x T	NS	NS	NS	NS	NS	NS
N x T	S	S	S	S	NS	NS
C x N x T	NS	NS	NS	NS	NS	NS

T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS + 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading

Conclusion

It can be concluded that crop establishment under zero till-DSR nourished with 150 kg N ha^{-1} in three splits of nitrogen 33.3 % at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage should be followed to achieve better crop growth, higher level of yields and it fetches better economic returns in direct seeded rice.

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