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Effect of different levels of nitrogen on growth and yield parameters in rice (*Oryza sativa* L.) varieties

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Abstract
An investigation was carried out during *Kharif-2019* and *Kharif-2020* to study the response of rice varieties on growth and yield parameters under four nitrogen levels (0, 120, 240 and 360 kg N ha-1) as main treatments and three varieties *viz*. BPT5204, NDLR-7 and NLR 34449 as sub treatments. In the present investigation among the varieties V_2 recoded significantly higher values for growth parameters such as plant height at tillering stage, panicle initiation stage, flowering stage and harvest stage) (35, 70.65, 103.89, 105.65 cm) and higher dry matter per plant at panicle initiation stage, flowering stage (3.17, 5.28, 11.0 g plant^{-1}) and recorded higher no. of productive tillers (9.50) maximum grain yield 5681.03 kg ha^{-1}. The interaction effect is significant and higher yield was recorded in the combination of 120 kg N ha^{-1} in NDLR-7 (7496.77 kg ha^{-1}) and lowest grain yield was recorded in the combination of 360 kg N ha^{-1} in BPT 5204 (3141.66 kg ha^{-1}). We concluded that with the increasing the N application dose the varieties response is varied significantly but with the higher dose of N all the varieties recoded lower yields. Hence application of the intermediate level of nitrogen was economical and environment-friendly.

Keywords: Rice, variety, growth, yield, dry matter production, productive tillers

Introduction

Rice is one of the most important cereal crops of the world which feeds half of the world's population providing 35-60% of the total calorie (Tayefe *et al.*, 2014) [12]. During past few decades, rice production increased mostly due to adoption of high yielding varieties, increase in irrigated area and use of chemical fertilizers. However, the rate of increase in rice yield is static and if the rate is not possible to increase, severe food shortage is likely to occur in near future. To push up the yield ceiling, sustainable technologies are essential, which are economically viable and environmentally friendly. Cost minimization by saving resources and development of low cost technologies must be considered in rice production. Among the crop management practices, judicious application of nitrogenous fertilizer is paramount important for yield enhancement of rice.

Among the major nutrient elements, nitrogen (N) is the most limiting nutrient for rice crop growth and yield which is required in higher amounts compared to other nutrients (Djaman *et al.*, 2018) [10]. N influences rice yield by playing major role in the photosynthesis, biomass accumulation, effective tillering, and spikelets formation (Yoshida *et al.*, 2006) [13]. Therefore, N fertilization is imperative for modern rice varieties in order to exploit their full yield potential (Chamely *et al.*, 2015) [4]. High yielding modern rice varieties show a greater response to applied nitrogen, while they differ in N demand depending on their genotype and agronomic traits under different climatic conditions (Rahman *et al.*, 2007) [11]. On the other hand, excessive N application can lead to ground water pollution, increased production cost, reduced yield and environmental pollution (Djaman *et al.*, 2018) [10].

Therefore, it is essential to achieve efficient use of nitrogen in chemical fertilizers, through cultivation techniques and fertilizer management with high nitrogen use efficiency and reducing nitrogen inputs from farming to the environment. Evaluating the reaction of rice to diverse doses of nitrogen will aid in the development of high nitrogen use efficiency varieties, and the screening of appropriate genotypes for all cultivated condition. Numerous studies have investigated varietal variation in yield and Nitrogen use efficiency. Samonte *et al*. have pointed out that representative varietal variation in yield and nitrogen use efficiency was complex because rice yield was influenced by inherent factors such as the number of productive culms, grains per panicle and 1000 grain weight, in addition to plant management

conditions. However, measuring genotypic differences in dry matter production and nitrogen use efficiency at the vegetative growth stage eliminates those additional variables affecting yield. Understanding the mechanisms regulating the processes of nitrogen uptake, assimilation, utilization efficiency and remobilization are crucial for the improvement of nitrogen use efficiency in crop plants. One important approach is to develop an understanding of the plant response to different nitrogen regimes and studying plants that show better growth under nitrogen limiting conditions. Studies on impacts of elevated nitrogen on growth dynamics, biomass partitioning, chaffy grain and nitrogen use efficiency are limited.

Hence, the objective of this study was to investigate varietal differences in response to elevated doses of nitrogen fertilizer among 3 rice varieties to provide essential information for the breeding of varieties that are suitable for cultivation with less application and reduced dose of N fertilizer for eco-friendly sustainable agriculture.

Materials and Methods

A field experiment was conducted during the *kharif*-2019 and *Kharif*-2020 at college farm, agricultural college, Mahanandi, ANGRAU, Guntur. The experiment was laid out in a split plot design with four nitrogen levels *i.e.* 0 (Control), 120 kg N ha^{-1}, 240 kg N ha^{-1} 360 kg N ha^{-1} and three varieties viz BPT 5204 (V_1), NDLR-7 (V_2) and NLR34449 (V_3) as sub treatments and the experiment was replicated thrice. The rice varieties were sown separately in raises bed nursery thirty-day old seedlings were transplanted in to 12 m^2 (4m x 3m) plot by adopting a spacing 20 cm between rows and 15cm between plants with in row. Nitrogen was applied as per the treatments 120 kg N ha^{-1}, 240 kg N ha^{-1} 360 kg N ha^{-1} in three equal splits in the form of urea. Depending on the nitrogen treatment one third dose of nitrogen was applied as basal dose at the time of planting of the crop. Remaining two equal splits of nitrogen was broadcasted at maximum tillering and panicle initiation stages. Phosphorus was applied at the rate of 60 kg P_2O_5 ha^{-1} in the form of single super phosphate and potassium 40 kg K_2O ha^{-1} in the form of muriate of potash applied as basal dose at the time of transplanting. Irrigation and weed management was done in time to time. The border rows were harvested first and then the net plot area was harvested and the produce was threshed by beating on threshing bench cleaned and sun dried to 14 per cent moisture level. Plants in one m^2 area were tagged separately.

Growth Parameters

Plant Height: Five plants were selected randomly from individual plots and properly tagged. Their height were measured in centimeters form ground level. Observations were taken at different growth stages like tillering stage, panicle initiation stage, flowering and harvest stage.

Dry matter production: For calculation of dry matter production plant samples were taken from each plot at different growth stages. From these sample plants the roots, green leaves and stems were separated and kept in brown paper packet and were allowed to dry in hot air oven at a temperature of 650 ºC for 24 hours and continued till their constant weight were recorded.

Yield parameters

No. of productive tillers per plant: The number of both ear bearing and nonbearing tiller per plant were counted at the time of the harvest and reported as tiller per plant. At harvest tillers bearing panicles were counted and expressed as effective tiller per plant.

Grain yield: Grain from net plot area was thoroughly sun dried, threshed, cleaned and weigh of the grains was recorded and expressed in yield per ha.

The data was analyzed statistically following the method given by Panse and Sukhatme (1987) [16] and wherever the results were significant the critical difference (CD) was calculated at 5 per cent level of significance (p = 0.05)

Results and Discussion

Growth Parameters

Plant Height: The date on plant height at different growth stages *i.e.* tillering stage, panicle initiation stage and harvest stage was given in Table.1. Pooled data on nitrogen levels revealed that nitrogen application at the rate of N_4 (360 kg N ha^{-1}) achieved significantly tallest plants at all growth stages (35, 70.65, 103.89, 105.65 cm) followed by 240 kg N ha^{-1}(N_3), and 120 kg N ha^{-1} (N_2) Similar response of enhanced plant height at higher nitrogen levels was reported in rice Hukum Sigh *et. al.* (2015) [17].

Among the three varieties NDLR-7 (V_2) produced tallest plants at all growth stages (36.68, 77.62, 113.2, 113.83 cm) *i.e* tillering stage, panicle initiation, flowering and harvest stage followed by BPT 5204 (V_1) and lowest plant height was recorded in NLR 34449 (V_3). Similar response of varied plant height among rice varieties reported in rice by Kumar *et al.* (2015) [18].

Pooled data on interaction effects revealed that highest plant height was recorded in NLDR-7 in response to 120 kg N per ha-1 application followed by 360 kg N ha^{-1} and NLR 34449 at the rate of 360 kg N ha^{-1}. The data indicates that NDLR-7 showed higher response to enhanced nitrogen application followed by NLR 3449. This effect was clearly evidenced in terms of susceptibility to lodging. NDLR 34449 more prone to lodging followed by NDLR-7.

Dry matter production

Data pertaining to dry matter production of rice varieties influenced by varied nitrogen levels was recorded at tillering stage, panicle initiation stage, flowering stage and harvest stage in *Kharif-2019* and *Kharif-2020* are presented Table 2. Dry matter production is the important index reflecting the growth and metabolic efficiency of the plant which ultimately influences the yield of the crop.

Pooled data on nitrogen levels revealed that nitrogen application at the rate of 360 kg N ha^{-1} (N4) at tillering stage, panicle stage flowering stage (3.17, 5.28,11.0) expect harvest stage followed by 120 kg N ha^{-1}(N_2). Similar response of enhanced dry matter production at higher nitrogen levels was reported in rice by (Md Anamul Haque *et al.*, 2016) [14].

Among the three varieties NDLR-7 (V_2) recorded significantly higher dry matter production at tillering stage (3.70 g $plant^{-1}$), panicle initiation stage (4.86 g $plant^{-1}$) and flowering stage (11.2 g $plant^{-1}$) compared to BPT 5204 (V_1) and NLR 34449 (V_3). Pooled data on interaction effects revealed that highest dry matter production was recorded in NLDR-7 (21.60 g $plant^{-1}$) and NLR 34449 (19.57 g $plant^{-1}$) in response to 120 kg N per ha^{-1} application followed by 240 kg N ha^{-1} and NLR 34449 at the rate of 360 kg N ha^{-1}. The data

indicates that NDLR-7 showed lower response to enhanced nitrogen application followed by NLR 34449.

However, effect of enhanced nitrogen level over recommended dose (120 kg N ha^{-1}) on BPT 5204 was more and recorded very less dry matter production (13.51g $plant^{-1}$). The complete yellowing and drying of leaves was observed. Azarpour *et.al.* (2014) [1] reported that elevated nitrogen supply can boost dry matter content through production of photo-assimilates via leaves which is the center of plant growth during vegetative stage and later distribution of assimilates to the reproductive organs. Furthermore, dry matter production in rice is significantly related to intercept photo synthetically active radiation.

Yield and yield attributes

No. of productive tillers per plant

Data pertaining to number of productive tillers per plant of rice varieties influenced by varied nitrogen levels was recorded at harvest stage in *Kharif-2019* and *Kharif-2020* are presented in Table 3. Pooled data on nitrogen levels revealed that nitrogen application at the rate of 120 kg N ha^{-1} (N2), 240 kg N ha^{-1}(N_3), 360 kg N ha^{-1} (N_4) recorded significantly higher no. of productive tillers per plant compared to control (N_1).

Pooled data on nitrogen levels revealed that nitrogen application at the rate of 120 kg N ha^{-1} (N2) recorded significantly higher no. of productive tillers per plant (9.50) and lowest no of productive tillers are recorded are in control (7.23) (N_1). Similar response of higher no of productive tillers at higher nitrogen levels was reported in rice (Afsana Jahan *et al.*, 2020, Biswajit Saha *et al.*,2017) [2, 3].

Pooled data on interaction effects revealed that higher no of productive tillers per plant are recorded in NLDR-7 (10.4) in response to 120 kg N per ha^{-1} followed by same variety at 360 kg N ha^{-1}.

Table 1: Effect of different levels of N levels on plant height (cm) of rice (*Oryza sativa* L.) varieties at tillering stage, panicle initiation stage, flowering stage and harvest stage during *Kharif-2019* and *Kharif-2020*

Treatments	Tillering Stage			Panicle Intiation Stage			Flowering Stage			Harvest Stage		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
N application rate												
M1 (N-0 Kg/ha)	32.02	33.58	32.34	62.43	63.60	62.79	90.38	95.87	93.13	95.80	97.29	96.15
M2 (N-120 N kg/ha)	30.03	34.08	34.36	62.01	73.55	67.78	96.98	100.12	98.55	101.57	102.68	102.13
M3 (N-240 KgN/ha)	33.21	35.45	35.20	61.92	76.90	69.41	99.25	98.36	98.80	99.56	101.07	100.32
M4 (N-360 KgN/ha)	34.79	34.99	35.00	64.79	76.51	70.65	103.77	104.00	103.89	105.36	105.93	105.65
S.E(m)	3.00	0.74	0.30	3.16	1.18	1.51	0.14	2.00	0.94	3.41	3.27	3.31
C.D (p = 0.05)	10.378	2.576	1.02	10.92	4.07	5.23	0.497	6.92	3.251	11.80	11.33	11.45
Varieties												
S1 (BPT 5204)	32.50	33.90	32.80	61.04	70.38	65.54	93.23	94.24	93.7	96.22	97.86	97.17
S2 (NDLR-7)	33.35	34.67	36.68	70.46	84.78	77.62	112.31	114.04	113.2	111.06	111.10	110.66
S3 (NLR34449)	31.68	35.01	33.20	56.86	62.76	59.81	87.25	90.48	88.9	94.45	96.27	95.36
S.E(m)	1.94	1.52	0.43	2.09	1.31	1.51	0.27	1.38	0.7	1.04	1.32	1.22
C.D (p = 0.05)	5.81	4.55	1.29	6.26	3.93	4.52	0.80	4.13	2.2	3.13	3.95	3.64

Interaction	Tillering stage			Panicle intiation stage			Flowering stage			Harvest stage		
	2019	2020	Pooled	2019	2019	2020	Pooled	2019	2019	2020	Pooled	2019
M_1S_1	32.18	34.18	32.50	62.98	60.96	61.3	85.94	89.68	87.8	92.69	95.69	94.69
M_1S_2	32.04	29.21	30.96	67.70	74.20	70.9	106.16	112.73	109.4	107.30	105.15	104.56
M_1S_3	31.83	37.37	33.57	56.61	55.63	56.1	79.06	85.19	82.1	87.41	91.03	89.22
M_2S_1	31.59	31.33	31.89	56.59	71.53	64.1	93.22	95.40	94.3	97.23	98.33	97.78
M_2S_2	26.05	31.53	34.30	78.16	86.71	82.4	114.08	115.37	114.7	113.06	114.26	113.66
M_2S_3	32.45	39.39	36.90	51.29	62.42	56.9	83.64	89.59	86.6	94.42	95.45	94.94
M_3S_1	33.09	33.41	33.38	61.57	72.99	67.3	92.37	91.70	92.0	98.60	100.80	99.70
M_3S_2	36.97	42.83	42.34	71.69	91.81	81.7	112.91	112.21	112.6	109.49	109.89	109.69
M_3S_3	29.56	30.12	29.89	52.51	65.90	59.2	92.47	91.16	91.8	90.59	92.53	91.56
M4S1	33.15	36.69	33.43	63.01	76.03	69.5	101.38	100.20	100.8	96.36	96.63	96.49
M4S2	38.33	35.12	39.13	64.30	86.42	75.4	116.09	115.84	116.0	114.37	115.10	114.73
M4S3	32.89	33.17	32.43	67.05	67.08	67.1	93.84	95.97	94.9	105.37	106.05	105.71
Mean	32.51	34.53	34.22	62.79	72.64	67.66	97.60	99.59	98.59	100.57	101.74	101.06
G x S												
S.E(m)	3.88	3.03	0.86	4.18	2.62	3.02	0.53	2.75	1.47	2.09	2.64	2.43
C.D (p = 0.05)	11.63	9.09	2.59	12.53	7.85	9.05	1.60	8.26	4.41	6.26	7.90	7.29

Table 2: Effect of different levels of nitrogen on dry matter production (g $plant^{-}1$) of rice (*Oryza sativa* L.) varieties at tillering stage, panicle initiation stage, flowering stage and harvest stage during *Kharif-2019* and *Kharif-2020*

Treatments	Tillering stage			Panicle initiation stage			Flowering stage			Harvest stage		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
N application rate (N)												
N1 (Control)	2.89	3.05	2.97	3.97	4.72	4.34	10.61	11.33	10.97	16.23	17.39	16.81
N2 (120 Kg N ha-1)	3.22	3.45	3.33	5.11	5.24	5.18	11.05	10.87	10.96	19.53	20.44	19.98
N3 (240 Kg N ha-1)	2.80	3.55	3.17	4.42	4.66	4.54	10.98	11.33	11.16	14.33	16.73	15.53

N4 (360 Kg N ha-1)	4.14	4.69	4.41	5.05	5.51	5.28	11.30	10.70	11.00	16.43	15.87	16.15
S.E(m)±	0.50	0.52	0.51	0.22	0.40	0.29	0.24	0.36	0.24	1.06	1.31	1.10
C.D (p = 0.05)	1.726	1.80	1.76	0.77	1.37	1.01	0.82	1.24	0.83	3.65	4.54	3.80
Varieties(V)												
V1 (BPT 5204)	3.07	3.40	3.23	4.65	5.13	4.89	10.88	11.07	11.0	15.31	16.35	15.83
V2 (NDLR-7)	3.42	3.97	3.70	4.65	5.08	4.86	11.17	11.15	11.2	17.05	18.04	17.55
V3 (NLR34449)	3.30	3.69	3.49	4.60	4.89	4.75	10.90	10.96	10.9	17.53	18.42	17.98
S.E(m)±	0.15	0.18	0.15	0.32	0.23	0.23	0.31	0.34	0.3	1.19	0.93	1.03
C.D (p = 0.05)	0.46	0.54	0.44	0.95	0.69	0.68	0.93	1.03	0.9	3.57	2.80	3.10

Interaction	Tillering stage			Panicle initiation stage			Flowering stage			Harvest stage		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	pooled	2019	2020	Pooled
M_1S_1	2.41	2.64	2.52	3.76	4.74	4.2	10.41	11.42	10.9	15.95	16.38	16.16
M_1S_2	2.90	3.00	2.95	4.25	4.67	4.5	10.63	10.66	10.6	16.74	18.65	17.69
M_1S_3	3.37	3.52	3.44	3.89	4.75	4.3	10.80	11.91	11.4	16.01	17.14	16.57
M_2S_1	3.06	3.14	3.10	5.01	5.01	5.0	11.06	10.55	10.8	19.20	18.35	18.78
M_2S_2	4.45	4.85	4.65	5.69	6.00	5.8	11.73	11.63	11.7	21.10	22.10	21.60
M_2S_3	2.14	2.35	2.25	4.64	4.71	4.7	10.35	10.44	10.4	18.28	20.86	19.57
M_3S_1	2.94	3.41	3.17	4.20	4.72	4.5	10.72	11.55	11.1	13.28	16.45	14.86
M_3S_2	2.36	3.11	2.74	4.32	4.52	4.4	10.78	11.40	11.1	12.13	15.11	13.62
M_3S_3	3.09	4.12	3.60	4.73	4.75	4.7	11.44	11.04	11.2	17.57	18.62	18.09
M4S1	3.85	4.40	4.13	5.65	6.07	5.9	11.32	10.74	11.0	12.81	14.22	13.51
M4S2	3.97	4.93	4.45	4.34	5.11	4.7	11.57	10.91	11.2	18.24	16.31	17.28
M4S3	4.59	4.75	4.67	5.16	5.34	5.2	11.02	10.46	10.7	18.25	17.08	17.66
Mean	3.26	3.69	3.47	4.64	5.03	4.83	10.99	11.06	11.02	16.63	17.60	17.12
N x V												
S.E(m)	0.31	0.36	0.29	0.64	0.46	0.45	0.62	0.69	0.59	2.38	1.87	2.07
C.D (p = 0.05)	0.92	1.08	0.88	1.90	1.37	1.36	1.86	2.06	1.76	7.14	5.60	6.20

Table 3: Effect of different levels of nitrogen on no. of productive tillers and grain yield (kg ha^{-1}) of rice (*Oryza sativa* L.) varieties at harvest stage during *Kharif-2019* and *Kharif-2020*

Treatments	No. of Productive tillers plant^{-1}			Grain yield kg ha^{-1}		
	2019	2020	Pooled	2019	2020	Pooled
N application rate (N)						
N_1 (Control)	7.16	7.31	7.23	4257.50	4277.02	4267.26
N_2 (120 Kg N ha^{-1})	9.56	9.44	9.50	5867.83	5735.78	5801.80
N_3 (240 Kg N ha^{-1})	9.29	8.83	9.06	4963.49	5203.18	5083.34
N_4 (360 Kg N ha^{-1})	9.33	9.46	9.39	4494.44	4639.44	4566.94
S.E(m)±	0.39	0.12	0.20	152.45	377.51	216.66
C.D (p = 0.05)	1.34	0.42	0.68	527.58	1306.40	749.76
Varieties(V)	8.80	8.59	8.70			
V_1 (BPT 5204)	9.22	9.21	9.21	4338.19	4072.32	4205.25
V_2 (NDLR-7)	8.48	8.48	8.48	5602.28	5759.79	5681.03
V_3 (NLR34449)	0.30	0.25	0.23	4746.97	5059.46	4903.22
S.E(m)±	0.90	0.74	0.69	187.33	290.93	187.35
C.D (p = 0.05)	7.16	7.31	7.23	561.63	872.25	561.70

Interaction	No. of Productive tillers			Panicle initiation stage		
	2019	2020	Pooled	2019	2020	Pooled
M_1S_1	7.20	7.70	7.5	4113.89	4228.89	4171.39
M_1S_2	7.47	7.30	7.4	4461.11	4494.87	4477.99
M_1S_3	6.80	6.92	6.9	4197.50	4107.30	4152.40
M_2S_1	9.47	8.63	9.1	5025.00	4574.17	4799.58
M_2S_2	10.53	10.33	10.4	7530.93	7462.61	7496.77
M_2S_3	8.67	9.37	9.0	5047.56	5170.56	5109.06
M_3S_1	9.87	9.10	9.5	5113.88	4344.55	4729.22
M_3S_2	8.93	9.37	9.2	4725.42	5496.67	5111.04
M_3S_3	9.07	8.03	8.6	5051.17	5768.33	5409.75
M4S1	8.67	8.93	8.8	3099.99	3141.66	3120.83
M4S2	9.93	9.83	9.9	5691.67	5585.00	5638.33
M4S3	9.40	9.60	9.5	4691.67	5191.67	4941.67
Mean	13.16	13.72	13.50	4895.82	4963.86	4929.84
N x V						
S.E(m)	0.60	0.49	0.46	374.65	581.87	374.70
C.D (p = 0.05)	1.80	1.47	1.38	1123.26	1744.51	1123.40

Grain yield

Data pertaining to grain yield per ha of rice varieties influenced by varied nitrogen levels was recorded at harvest stage in *Kharif-2019* and *Kharif-2020* are presented in Table 4. Pooled data on nitrogen levels revealed that nitrogen application at the rate of 120 kg N ha^{-1} (N2), recorded significantly higher grain yield per ha^{-1} (5801.18 kg ha^{-1}) followed by 240 kg N ha-1 and lowest was recorded in control (N_1). Similar response of enhanced grain yield at higher nitrogen levels was reported in rice (Biswajit Saha *et al.*, 2017) [3].

Among the three varieties NDLR-7 (V_2) recorded significantly higher grain yield (5681.03 kg ha^{-1}) followed by NLR 34449 (4903.22) and lowest grain yield was recoded in BPT 5204 (V_1) (4205.23) and Similar response of varied grain yield among rice varieties reported in rice (Biswajit Saha *et al.*, 2017) [3].

Pooled data on interaction effects revealed that higher grain yield was recorded in NLDR-7 response to 120 kg N per ha^{-1} followed by same variety at 360 kg N ha^{-1}. Lowest yield was recorded in BPT 5204 in response to 360 kg ha^{-1}

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