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Effect of Nitrogen and Phosphorus levels on growth and yield of direct-seeded rice *(Oryza sativa L.)* under Nagaland conditions

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ABSTRACT

A field experiment was conducted entitled "Effect of nitrogen and phosphorus levels on growth and yield of direct seeded rice (Oryza sativa L.) under Nagaland condition" during the kharif period i.e., June-October 2018, in the experimental research farm of the School of Agricultural Sciences and Rural Development, Nagaland University. Nine treatments comprising three levels of N (0, 50, 100 kg N ha^{-1}) and three levels of P (0, 40, 80 kg P_2O_5 ha^{-1}) were used. The study revealed that N_2 (100 kg N ha^{-1}), P_1 (40 kg P_2O_5 ha^{-1}) and interaction treatment T_8 (100 kg N: 40 kg P_2O_5) had performed significantly better as compared to other levels and combination treatments in terms of growth and yield in rice crop. Application of N and P levels significantly increased plant height (cm), number of tillers, crop growth rate (g g^{-1} day^{-1}) and relative growth rate (g g^{-1} day^{-1}). The highest grain yields (3687.96, 3687.96, 4442.42 kg ha^{-1}) were recorded with N_2, P_1 and T_8. Maximum straw yield was recorded with treatment levels of N_2 (7394.96 kg ha^{-1}), P_2 (6531.29 kg ha^{-1}) and T_8 (8284.06 kg ha^{-1}). The HI (%) was recorded highest with N_2 (33.42%), interaction treatment T_8 (35.59%) while P levels did not give any significant results.

Keywords: Nitrogen, Phosphorus, Rice, Growth, Yield, Soil chemical properties.

INTRODUCTION

Rice (*Oryza sativa* L.*)* comes under the family of Gramineae and is considered the most essential food crop in the world, feeding directly more people as compared to the other crops. Nagaland, basically an agricultural economy most of the population is dependant of agriculture. Rice is the dominant crop and also the staple diet of the people which under the food grains covers more than half of the gross cropped area. Practice of imbalanced fertilization by farmers with no proper knowledge creates hazardous effects both on farmer's health and soil. With judicious and proper use of fertilizer, yield and quality of rice can be improved (Alam *et al.*, 2009). Fertilizer application is a crucial input for production of rice where its profitability depends on input and yield quantities. Chemical fertilizer offers nutrient which are readily soluble in soil solution and thereby instantly available to plants. Appropriate fertilizer input is not only for getting high yield but also for attaining the maximum profitability (Khuang *et al.*, 2008). An adequate and balanced supply of plant nutrients is a prerequisite to maximise crop production. Nitrogen and Phosphorus are major nutrients which are required by the rice crop for vegetative growth as well as for yield production. Application of N increases leaf N and chlorophyll content which in turn increases the photosynthesis rate and eventually increase in dry matter production. The number of filled grains/panicle in later form tillers increases due to higher nitrogen. Phosphorus is also an important and essential plant nutrient for root development, tillering, early flowering, and ripening. Phosphorus deficiency is one of the most rice yield limiting factors in tropical acid soils (Fagaria *et al.*, 1997) (Fagaria *et al.*, 2011). The low natural P and high P immobilization is responsible for P deficiency in crop plants grown on these soils (Fagaria, 2009). Application of both the nutrients with the right amount and time will increase the fertilizer efficiency and thus improved yield of the crop. As about 40 percent of yield increase is accounted against fertilizer use, the fertilizer recommendation should be matched to the basic soil fertility, season, target yield, climate etc (Murthy *et al.*, 2015). Excess use of fertilizer nutrient implies increase of cost and decrease of returns with risk of environmental pollution.

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On the other hand, under use of nutrient depress the scope for increasing the present level to exploit production to a larger extent (Singh *et al.*, 2001). Application of inadequate and imbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma *et al.*, 2003). Presently the rice productivity of Nagaland is low compared to national average contributing less than a per cent of production in the country. The existing fertilizer recommendation for major nutrients in rice are proving to be sub-optimal for attaining higher productivity level and requires a revised recommendation on optimum and balanced levels. With the climate conditions and soil nutrient status of a particular area the correct levels of fertilizer needs to applied to the rice crop in order to obtain maximum yield. Hence special revised recommendations of nutrients should be considered to add these nutrients in adequate amounts to sustain rice production on these soils.

MATERIALS AND METHOD

The study entitled "Effect of Nitrogen and Phosphorus levels on growth, yield and soil chemical properties in direct- seeded rice (*Oryza sativa L.*) under Nagaland conditions" was carried out in the experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus, Nagaland, India from June to October, 2018. The farm lies in humid and sub-tropical climate with an average rainfall ranging from 2000- 2500 mm annually. The maximum rainfall is received during May to October. The mean temperature ranges from 21- 32℃ during summer and rarely goes below 8℃ in winter due to high atmospheric humidity. To ascertain the texture and fertility status of the soil, the soil samples were collected from different locations of the experimental field with soil auger randomly from 0-20 cm depth. Initial fertility status of the experimental field are pH 4.3, EC (dSm^{-1}) 0.35, Organic carbon (%) 2.30, NPK (kg ha^{-1}) 109.7, 5.6, 100.8 respectively. The field experiments were conducted following the Randomised Block Design (2 Factorial). A total of nine treatments (three levels of N (0, 50, 100 kg N ha^{-1}) and three levels of P (0, 40, 80 kg P_2O_5 ha^{-1}) were included to study its effect both in individual level and interaction of the two fertilizers on growth, yield and soil chemical properties in rice crop. The total area of the experimental plot was 184 cm^2 and each plot size with an area of 2m × 2m. Sabhagi Dhan, a dwarf drought tolerant variety released in the year 2009 was selected for the experimentation purpose maintaining a row spacing of 20cm × 10cm. The details of the treatments which are incorporated in the experiments includes different levels of inorganic fertilizers namely nitrogen through urea and phosphorus through SSP (single super phosphate) fertilizers for estimating their effects on the rice crop. For determining the vegetative growth characters like the plant height and number of tillers $plant^{-1}$, five plants in each plot were selected randomly, tagged and measured. The growth attributes were recorded at 35, 70 DAS and at harvest. The Crop Growth Rate (g $m^{-2}day^{-1}$) and Relative Growth Rate (g g^{-1} day^{-1}) was counted from the selected five plants in each plot at 35 and 70 DAS. The yield attributes namely number of panicles (m^{-2}), length of panicle $plant^{-1}$ (cm), number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$,number of unfilled grains $panicle^{-1}$, test weight (g) were calculated with the selected five plants and average was evaluated. The grains and straw obtained after harvesting was thoroughly sun dried and weight was taken to determine in terms of kg ha^{-1}. Harvest index (%) is the ratio of grain yield to biological yield expressed in percentage. Mean data of each quantitative trait were statistically analysed by the technique of analysis of variance. The significance difference was tested by 'f' test and differences between mean by using CD at 5% level.

RESULTS AND DISCUSSION

Growth attributes

In general, abundant supply of nitrogen and phosphorus nutrients contributes to the plant growth and development and higher nitrogen rates increases the plant height (Rahman *et al.*, 2007). Similar positive results have been recorded in all the treatments and treatment combinations under study. Critical examination in the Table 1 revealed that the highest plant heights (cm), number of tillers were recorded with the higher levels of nitrogen and phosphorus nutrients i.e., N2 (57.9cm, 87.2cm, 93.4 cm) and P2 (55.1cm,79.2cm, 9.22cm, 93.4cm)at all stages of pant growth.

Table 1: Effect of N and P levels on growth parameters of rice crop

Level	Plant height (cm)			No. of tillers		CGR (g $g^{-1}cm^{-1}$)		RGR (g g^{-1} cm^{-1})	
	35 DAS	70 DAS	At Harvest	35 DAS	70 DAS	35 DAS	70 DAS	35DAS	70DAS
N_0	48.7	66.14	75.95	1.82	2.3	3.02	16.66	0.013	0.021
N_1	52.06	78.34	92.11	2.05	2.78	4.15	19.26	0.017	0.019
N_2	57.96	87.2	93.45	2.19	2.88	5.1	25.47	0.02	0.02
SEm±	1.48	1.41	1.81	0.02	0.04	0.14	0.49	0.001	0.001
CD (P=0.05)	5.18	4.95	6.34	0.10	0.14	0.49	1.72	0.002	0.002
P_0	49.64	73.57	83.68	1.94	2.49	3.58	16.46	0.015	0.019
P_1	53.9	78.88	90.94	2.07	2.73	4.38	24.75	0.018	0.021
P_2	55.18	79.22	93.46	2.03	2.75	4.32	20.18	0.017	0.019
SEm±	1.48	1.41	1.81	0.02	0.04	0.14	0.49	0.001	0.001
CD (P=0.05)	5.18	4.95	6.34	0.10	0.14	0.49	1.72	0.002	0.002

N_0 = 0 kg ha^{-1}, N_1 =50 kg ha^{-1}, N_2 = 100 kg ha^{-1}; P_0 = 0 kg ha^{-1}, P_1 = 40 kg ha^{-1}, P_2 = 80 kg ha^{-1}
Values for no. of tillers have been subjected to ($\sqrt{x+0.5}$) transformation

Also the combination treatment T_8 (64.9cm, 89cm, 89.3cm, 100cm) depicted in Table 2 proved to perform better than the other treatments at all stages of plant growth also significantly at par with T_7 and T_9. The enhancement of the rice plant height due to the application of the N and P fertilizers is apparent as N is essential for plant growth since it is the constituent of all nucleic and protein synthesis whereas P is essential for the production and transfer of energy in plants (Heluf and Mulugets, 2006) N_2 (2.19, 2.88) gave the highest no. of tillers while for P levels P_1 (2.07) gave the highest at 30 DAS and P_2 (2.75) at 70 DAS but statistically at par with P_1(2.73). Interaction treatment T_8 (2.98, 5.49) recorded the highest over all other treatments at both stages. Increasing dry matter accumulations have been determined with increasing mineral fertilizer rates of applied N (Hari *et al.*, 1997) which are apparently attributed to its effects in enhancing vigorous vegetative growth of the rice plant (Heluf and Mulugets, 2006). In this study, dry matter accumulation was positively and significantly associated ($P \le 0.05$) with plant height, number of tillers and other yield attributes. Table 1 shows that dry matter accumulations factors like CGR and RGR were increased with higher level of nitrogen N_2. Increasing the level of applied P increased the dry matter accumulation significantly from 0 kg ha^{-1} to 40 kg ha^{-1}, but further increment of the P level to 80 kg ha^{-1} showed a decrement in the dry matter accumulation of the rice plant.

Table 2: Interaction effect of N and P on growth parameters of rice crop

Level	Plant height (cm)			No. of tillers		CGR (g $g^{-1}cm^{-1}$)		RGR (g g^{-1} cm^{-1})	
	35 DAS	70 DAS	At Harvest	35 DAS	70 DAS	35 DAS	70 DAS	35 DAS	70 DAS
T_1	41.43	56.46	66.33	1.59	1.94	2.62	10.99	0.012	0.018
T_2	50.46	72.63	83.60	1.03	2.42	3.25	19.32	0.014	0.022
T_3	54.2	69.33	89.93	1.94	2.52	3.2	19.67	0.014	0.022
T_4	53.86	77.86	92.73	2.09	2.74	3.69	17.98	0.016	0.020
T_5	46.33	74.7	89.23	2.00	2.77	4.41	21.41	0.018	0.020
T_6	56.00	82.46	94.36	2.05	2.84	4.37	18.40	0.018	0.018
T_7	53.63	86.4	92.00	2.16	2.78	4.43	20.42	0.017	0.019
T_8	64.9	89.33	100	2.29	2.98	5.49	33.51	0.021	0.022
T_9	55.36	85.86	96.06	2.12	2.89	5.39	22.48	0.02	0.018
SEm±	2.45	2.45	3.94	0.05	0.07	0.24	0.85	0.001	0.001
CD (P=0.05)	8.97	8.58	10.98	0.17	0.24	0.85	2.98	0.004	0.003

T_1 = control; T_2 = 0 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}; T_3 = 0 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1}; T_4 = 50 kg N ha^{-1}, 0 kg P_2O_5 ha^{-1}; T_5 = 50 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}; T_6 = 50 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1}; T_7 = 100 kg N ha^{-1}, 0 kg P_2O_5 ha^{-1}; T_8 = 100 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}; T_9 = 100 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1},
Values for no. of tillers have been subjected to ($\sqrt{x+0.5}$) transformation

Treatment combination T8 showed higher dry matter accumulation significantly as compared to the other treatments and control plot. Thus the results showed that the combination effect promoted plant growth and fertilization with the optimum dose of nitrogen and phosphorus, plant growth rate (dry matter production) increased significantly up to two to three fold (Elloitt and Abbott, 2003).

Yield attributes

The different yield parameters were found to be significantly improved by the addition of nitrogen and phosphorus nutrients at different levels. Critical examinations in Table 3 shows that with the application of nitrogen level N2 @100 kg ha^{-1} observed increment in number of panicle m^{-2} as compared to N1 and N0. Increment in the number of panicles m^{-2} due to applied P by enhancing the number of productive tillers (Zaman *et al.*, 1995) in which Table 4 show P2 (15.77) recorded significantly higher number of panicles compared to P1 (15.36) and P0 (13.97) but statistically at par with P1. Combination treatments showed positive increment in the number of panicles from 18.32 (T1) to 24.36 (T8) with the higher levels of nitrogen and phosphorus but statistically accorded to be non- significant. Increasing the level of nitrogen advantageously recorded higher length of the panicle higher from 21.04cm (N0) to 22.73cm (N2) as higher doses of nitrogen resulted in higher length of rice crop panicle (Ahmed *et al.*, 2005) and are positively correlated with panicle number m^{-2}, plant height, dry matter yield, grain yield and straw yield (Heluf and Mulugets, 2006). Application of phosphorus level P1 proved to have performed better comparatively with P2 and P0 for the length of panicle but statistically at par with P2.

Table 3: Effect of N and P levels on yield parameters of rice crop

Level	No. of paniclesm^2	Length of panicle (cm)	No. of grains panicle^{-1}	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	Test weight per 1000 seeds (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index (%)
N_0	13.88	21.04	10.24	9.36	5.61	29.69	2277.91	5371.15	29.61
N_1	14.75	22	11.40	9.39	5.42	29.4	3042.05	6014.84	33.05
N_2	15.72	22.73	12.48	10.26	4.85	30.26	3687.96	7394.96	33.42
SEm±	0.33	0.34	0.11	0.16	0.13	0.53	88.38	120.50	0.69
CD(P=0.05)	1.18	1.2	0.39	0.57	0.47	1.870	309.09	421.44	2.43
P_0	13.93	20.78	10.5	9.12	5.74	29.63	2615.22	5733.61	30.94
P_1	15.36	22.68	11.79	10.31	4.89	29.94	3289.80	6516.06	32.95
P_2	15.77	22.32	11.84	9.57	5.25	29.68	3102.9	6531.29	32.19
SEm±	0.33	0.34	0.11	0.16	0.13	0.53	88.38	120.509	0.69
CD(P=0.05)	1.18	1.2	0.39	0.57	0.47	1.87	309.09	421.44	2.43

N_0 = 0 kg ha^{-1}, N_1 =50 kg ha^{-1}, N_2 = 100 kg ha^{-1}; P_0 = 0 kg ha^{-1}, P_1 = 40 kg ha^{-1}, P_2 = 80 kg ha^{-1}

Values for no. of panicles m^{-2}, no. of grains, filled and unfilled grains panicle^{-1} have been subjected to ($\sqrt{x+0.5}$) transformation

The interaction effect of the nitrogen and phosphorus fertilizer rates on the panicle length showed increments as in treatment combination shown in the Table 4, T8 recorded the highest panicle length of 24.26 cm and lowest length of 18.32 cm with T1 control plot. Statistically T8 was found to be at par with T6 (22.69 cm), T3 (22.30 cm), T2 (22.50 cm). Similar trends of results with respect to the number of grains panicle^{-1}, filled and unfilled grains panicle^{-1} is observed which are depicted in the Table 4. Nitrogen level N2 @ 100 kg ha^{-1}proved to give significantly higher grain per panicle (12.48) compared to the other N levels as nitrogen increase the growth, yield components and number of rice grains per panicle evidently found maximum with an application of 80 kg N ha^{-1} (Rahman *et al.*, 2007). Increasing levels of P up to P2 @80 kg ha^{-1} also significantly increased the number of grains and filled grains panicle^{-1} as compared to P1 and P0 but the response for P2 and P1 were found to be statistically at par with each other indicating that application of P increases the total number of spikelets per panicle in rice thereby contributing to increment in number of grains and yield as a whole. Contrastingly filled grains panicle^{-1} were found to be higher with P_1 (10.31) compared to higher level of P nutrients P_2 (9.57) as with increase in soil fertility, the number of filled spikelets decreases. The interaction effect of N and P was found to be non significant statistically for the number of grains panicle^{-1} whereas for the number of filled grains panicle^{-1} combination treatment of N and P i.e., T_8 proved to give better results (11.18) as compared to the control treatment (7.49). Increase unfilled grains have been observed in the controls plots due to limited nutrients which are needed for the metabolic supply among the spikelets as the treatments with no application of nutrients N_0, P_0 and T_1 recorded the highest unfilled grains 5.61, 5.74 and 6.07 against N_2, P_2 and T_8 with 4.85, 4.89and 4.46 respectively. The test weight in all the treatments was found to be non-significant which varied from N_0 29.13g to N_2 30.26g for the N levels and statistically at par with each other (29.63g, 29.94g, and 29.68g) for all the phosphorus levels. In the combination a treatment, highest was recorded with T_8 (30.46g) and T_6 as the lowest (29.13g) but non-significant effect was found with the combination treatments on the test weight. Grain yield can be dependent on the various morphological components of yield such as plant height, number of panicles per unit area, number of grains per panicle or grain weight (Ochwoh *et al.*, 2015). Higher rates of nitrogen and phosphorus significantly and positively affected the grain yield as N_2 (3687.96 ha^{-1}), P_1 (3289.8 kg ha^{-1}) at par with P_2 (3102.9 kg ha^{-1}) and interaction treatment T_8 (4442.42 kg ha^{-1}) recorded the highest grain yield kg ha^{-1} as compared to the other treatments and control plot which recorded the lowest as shown in Table 4.

Table 4: Interaction effect of N and P on yield parameters of rice crop

Treatment	No. of paniclesm^2	Length of panicle (cm)	No. of grains panicle^{-1}	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	Test weight per 1000 seeds (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index (%)
T_1	12.22	18.32	8.88	7.94	6.07	29.46	1890.19	5033.13	27.31
T_2	14.01	22.5	10.79	10.35	4.91	29.66	2384.91	5430.24	30.46
T_3	15.42	22.3	11.05	9.78	5.83	29.66	2448.64	5654.09	31.06
T_4	14.36	22.04	11.07	9.29	5.46	29.36	2691.91	5833.73	31.54
T_5	15.08	21.27	11.6	9.39	5.16	29.7	3042.07	5833.87	32.8
T_6	14.81	22.69	11.57	9.47	5.65	29.13	3392.17	6376.93	34.83
T_7	15.22	21.97	11.58	10.13	5.69	30.06	3263.57	6333.96	33.98
T_8	17.84	24.26	12.97	11.18	4.61	30.46	4442.42	8284.06	35.59
T_9	17.09	21.97	12.9	9.47	4.26	30.26	3357.89	7566.85	30.69
SEm±	0.58	0.59	0.19	0.28	0.23	0.92	153.06	208.72	1.2
CD(P=0.05)	2. 04	2.09	0.68	0.99	0.81	3.24	535.37	729.95	4.21

T_1 = control; T_2 = 0 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}; T_3 = 0 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1}; T_4 = 50 kg N ha^{-1}, 0 kg P_2O_5 ha^{-1}; T_5 = 50 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}; T_6 = 50 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1}; T_7 = 100 kg N ha^{-1}, 0 kg P_2O_5 ha^{-1}; T_8 = 100 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}; T_9 = 100 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1}

Values for no. of panicles m^{-2}, no. of grains, filled and unfilled grains panicle^{-1} have been subjected to ($\sqrt{x+0.5}$) transformation

With closer observations it was observed that grain yield was highest with P rates @ 40 kg ha^{-1} and thereafter decreased both in individual P level and combined treatments. Increased dry matter accumulation due to increasing N and P rates promoted vigorous vegetative growth of rice plant and also increase N uptake (Heluf and Mulugets, 2006) (Zaman *et al.*, 1995). Increased levels of N rates attributed to higher straw yield significantly which was found highest (7394.96 kg ha^{-1}) with treatment N_2 followed by treatment N_1 (6014.84 kg ha^{-1}) and lowest (5371.15 kg ha^{-1}) with treatment N_0 (control).

Increasing the P rates also had significant effect on the straw yield where P_2 recorded higher (6531.29 kg ha^{-1}) straw yield over P_1 (6516.06 kg ha^{-1}) and P_0 (5733.61 kg ha^{-1}) but P_2 being statistically at par with P_1. Similar trend for the decrease in straw yield was also observed after P level @ 40 kg ha^{-1}. Combined application of N and P rates straw yield was found highest with T_8 (8284.06 kg ha^{-1}) followed by a decrement in straw yield in T_9 (7566.85 kg ha^{-1}) but both being statistically at par with each other. The above observation shows that higher N rates resulted in higher yield while P rates did not have much significant role as the straw yield started to fall after P@40 kg ha^{-1}. Combined application of N and P rates straw yield was found highest with T_8 (8284.06 kg ha^{-1}) followed by a decrement in straw yield in T_9 (7566.85 kg ha^{-1}) but both being statistically at par with each other. The above observation shows that higher N rates resulted in higher yield while P rates did not have much significant role as the straw yield started to fall after P@40 kg ha^{-1}. Harvest index was significantly higher for N_2 (33.42%) followed by N_1 (33.05%) and lowest with treatment N_0 (29.61%). Nitrogen levels N_2 and N_1 were statistically at par with each other. Thus with increasing level of nitrogen the HI was found to have increased significantly. In the phosphorus treatment, the HI ranged from 30.94% (P_0) to 32.19% (P_2) and there was nosignificant difference among the phosphorus treatments. Closer observation in the Table 4 shows that interaction treatment, T_8 was significantly higher (35.59 %) than the other treatments but statistically at par with T_6 (34.83%), T_7 (33.98%), T_5 (32.80%), T_4 (31.54%). The lowest harvest index (27.31%) was recorded from the control T_1 [N_0P_0].

Conclusion

The experiment conducted to study the effect of N and P and their interaction on direct seeded rice under Nagaland conditions revealed that N level @ 100 kg ha^{-1} and P @ 40 kg ha^{-1} both in individual and interaction treatment had more profound effect on the growth and yield parameters significantly compared to the other treatments, respectively. Thus taking into consideration the climate, soil conditions and critically analyzing the effects of each treatments applied in this experimental study, it can be concluded that fertilizer dose @ 100 kg N ha^{-1}, 40 kg P_2O_5 both in individual and combined treatment proved to be the ideal fertilizer dose for the rice crop under Nagaland conditions.

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