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Full Length Research Paper

Response of sensitive to lodging rice cultivar to nitrogen levels in heading stage and phosphorus rates at the North of Iran

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This experiment was done as factorial in randomized complete block design with three replications. Nitrogen levels in heading stage chosen as (0, 50 and 100 kg ha^{-1} as P_2O_5 Urea) and phosphorus rates as (0, 75, 150 and 225 kg ha^{-1} as P_2O_5 Urea) were treatment. Results showed that stem length, fourth inter-node bending moment, total tiller number per hill, fertile tiller per hill, grain yield and straw yield had significant in nitrogen levels at 1 % and plant height and panicle length had significant in nitrogen levels at 5 % level probability. The highest grain yield (590.1 g m2) was produced for 100 kg N ha^{-1}. Maximum straw yield was produced in 100 kg N ha^{-1}, and minimum of that had observed for control and 50 kg N ha^{-1}. The most plant height, flag leaf length, total tiller number and fertile tiller number were obtained for 50 and 100 kg N ha-1, but the highest forth inter-node bending moment was observed in control and 50 kg N ha^{-1}. Plant height, stem length, flag leaf length, and fourth inter-node bending moment increased 11.54, 11.99, 13.48, 6.78 % by phosphorus application. Lowest fourth inter-node bending moment had observed at interaction of 100 kg N ha^{-1} × control. The highest grain yield was produced at interaction of 100 kg N ha^{-1} × control. Therefore, application of 100 kg N in heading stage due to highest grain yield and rice plant was the best treatment, because of deficit phosphorus in soil, showed the best response to 225 kg P ha^{-1}.

Keywords: Lodging, nitrogen, phosphorus, rice, yield.

INTRODUCTION

Rice grown on clay soils typically requires more fertilizer N, even though native soil N concentrations are greater on clay soils. Nitrogen is important factor of growth limitation and lack of that caused decrease yield in each stage (Haefel *et al.,* 2006), as an essential input in most rice soils to achieve high yield. Lodging is a major problem in the production of cereal crops, because it causes decreases in yield and quality by reducing photosynthesis in the canopy, damages vascular bundles by bending or breaking stem, and causes problem associated with mechanical harvesting (Setter *et al.,* 1997). Stem bending type is the main type of lodging in rice; it is caused by the increase in panicle weight during maturation, and by environmental effects (i.e., rain and wind). Stem breaking occurs at lower internodes (below the third inter-node from the top) in response to bending higher up the stem (Islam *et al.,* 2007). Severe lodging prevents the transport of water, nutrients, and assimilates through the xylem and phloem, resulting in a reduction in assimilates for grain filling (Kashiwagi *et al.,* 2005). Current recommendations of split applications of N fertilizer with fixed rates at specific growth stages for large rice-growing areas assume the requirement of rice for N fertilizer is constant across large areas and years. The requirement of rice for N fertilizer can, however, vary greatly from location to location, season to season, and year to year because of high variability among fields, seasons, and years in N-supplying capacity of soil (Dobermann *et al.,* 2003). Most smallholder farmers have limited resources to purchase inputs such as expensive

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Table 1. Weather condition in experiment site in rice growth stages at Sari in 2011

Variable	Jan.	Feb.	March	April	May	June	July	August
Minimum tem.	2	4	9.3	7.5	14	18.8	23.1	23.7
Maximum tem.	12	14	15.2	16.4	24	27.8	32.6	33.2
Evaporation (mm)	40	50	43	58.1	75.8	135.1	128.2	152.6
Precipitation (mm)	62	85	78	124.9	26.9	29.4	8.1	11.9

Table 2. Selected soil properties for composite samples at experimental site at Sari in 2011

Soil texture	K (ppm)	P (ppm)	N (%)	OM (%)	pH	EC (µmohs/cm)	Depth (cm)
Clay loam	182	8.8	0.18	1.2	7.2	0.22	0-30

inorganic N fertilizers (Oikeh *et al.,* 2009). Topdressing of rice with N fertilizer is often based on the physiological development stage of the crop. For example, Asian rice is top-dressed at middle tillering or maximum tillering, and at about the stages of panicle initiation and flowering growth (Sahrawat *et al.,* 1995; Sahrawat, 2000). Furthermore, the N fertilizer rate that produced maximum grain yield also produced the highest head rice (whole milled rice) yield (Bond and Bollich, 2007). Nitrogen rates for optimum grain yield vary based on cultivar and soil texture (Bond *et al.,* 2006; Norman *et al.,* 2005; Walker, 2006). Excessive N application and poor N management reduce the profit of rice farmers by increasing production costs and reducing grain yield (Peng *et al.,* 2003). Poor resource management can also affect the emission of greenhouse gases (Matthews, 2003). The N content of rice at the panicle formation stage (about 10–15 d before flowering) has been shown to be an important determinant of sink size and eventual yields (Horie, 2001). Dobermann and Cassman, (2002) observed non-significant increases in fertilizer N efficiency in rice grown in different Asian countries during the past 30 year.

Phosphorus (P) is one of the major essential mineral nutrients, and is involved in many key metabolic pathways in plants. Within plant cells, the inorganic phosphate (Pi) concentration is generally >10 mM (>3 g kg^{-1}, on a biomass dry-weight basis), and yet the concentration in the soil solution is typically <10 µM, Because of the low concentration of the soluble form and slow rate of diffusion to the root surface, plants have therefore evolved a range of strategies to increase the availability and uptake of soil Pi (Marschner, 1995). Rice removes about 2 to 3 kg P for 1 Mg of grain produced (Timsina and Connor, 2001; Saleque *et al.,* 2001). Although the rice requirement for P is much less than that for N, the continuous removal of P exploits the soil P reserve if the soil is not replenished through fertilizer or manure application. Chemical P fertilizer is a costly agricultural input for rice farmers of the developing world, and sometimes the material is not available in the local village market. Cattle manure may be considered as an alternative to chemical P fertilizer. Many studies have shown that cattle manure can be a potential source of P (Reddy *et al.,* 2000). Eghball and Power, (1999) reported that manure application of 92 Mg ha^{-1} in four year increased soil available P at the 0 to 15 cm depth from 49 to 116 mg kg^{-1}. The greater accumulation of P due to manure application may increase the potential of P loss through run-off water (McDowell and Sharpley, 2001), but mixing the manure with soil may potentially decrease the problem of P loss (Kleinman *et al.,* 2003; Sharpley, 2003). Crops can only take up available P, but other fractions of P, such as NaOH-extracted inorganic and acid extracted P are depleted due to crop growth (Saleque and Kirk, 1995). The purpose of this experiment was consider response of sensitive to lodging rice cultivar to nitrogen and phosphorus fertilizer in north of Iran.

MATERIALS AND METHOD

In order to consider response of sensitive to lodging rice (*Oryza sativa* L.) cultivar (*var.* Tarom Hashemi) to nitrogen and phosphorus fertilizer, an experiment was carried out in 2011 at Sari, Mazandaran, Iran (36°, 4' N latitude and 53°, 5' E longitude at an altitude of 13.2 m above mean sea level). The soils of fields were clay-loam. The results of soil analyse is shown in Table 1 and the weather condition in growth season is shown in Table 2. The experimental was started in April 2011. This experiment was done as factorial in randomized complete block design with three replications. Nitrogen levels in heading stage chosen as (0, 50 and 100 kg ha^{-1} as Urea) and phosphorus rates as (0, 75, 150 and 225 kg ha^{-1} as P_2O_5) were treatment.

The rice cultivar in this experiment was Tarom Hashemi. The field was ploughed with tractor drawn disc plough followed by a through harrowing to break the clods. The field was properly levelled and 5 × 2 m^2 size plots were earmarked with raised bunds all around to minimize the movement of watering and nitrogen. Channels were laid to facilitate irrigation to plots individually and each replication had 12 plots. Before transplanting potassium (100 kg h^{-1}) was broad casting.

Table 3. Mean square of nitrogen levels in heading stage and phosphorus rates on lodging related traits of rice at Sari in 2011

S.O.V.	DF	Plant height	Stem length	Panicle length	Flag leaf length	Fourth internode length
Replication	2	6.00*	12.19	46.58*	130.08**	116.03**
Nitrogen (N)	2	106.08*	130.03**	56.83*	31.08**	24.19
Phosphorus (P)	3	264.07**	146.70**	6.70	15.21*	55.59*
N×P	6	12.60	9.07	7.29	3.27	4.12
E	22	20.82	12.86	12.04	4.33	12.69
C.V. (%)	-	4.20	4.22	13.97	9.01	12.85

** and * significant in 1 and 5% level, respectively.

Table 4. Mean comparison of nitrogen levels in heading stage and phosphorus rates on lodging related traits of rice at Sari in 2011

Treatment	Plant height (cm)	Stem length (cm)	Panicle length (cm)	Flag leaf length(cm)	Fourth internode length (cm)
Nitrogen levels					
0	105.4 b	83.75 b	25.00 ab	21.33 b	29.08 a
50 kg ha^{-1}	109.3 a	82.42 b	26.92 a	25.40 a	26.25 a
100 kg ha^{-1}	111.3 a	88.67 a	22.58 b	23.42 a	27.83 a
Phosphorus rates					
0	104.0 c	80.56 c	24.56 a	21.44 b	24.00 b
75 kg ha^{-1}	105.2 bc	83.67 bc	23.78 a	22.67 ab	29.00 a
150 kg ha^{-1}	109.4 b	85.33 b	25.22 a	23.89 a	28.78 a
225 kg ha^{-1}	116.0 a	90.22 a	25.78 a	24.33 a	29.11 a

Values within a column followed by same letter are not significantly different at Duncan ($P \leq 0.05$).

When rice seedlings were of 20 to 25 cm in height and 4 weeks old; they were uprooted and transplanted to experimental plots with 25 seedlings per m^2. Nitrogen levels in heading stage and phosphorus rates were done by design map. All operations like plant illnesses controlling and pests controlling were done during the growth process with chemical components. During the growth time, following characteristics was measured randomly from each plot. Plant height and stem length were measured from 12 hills in middle of each plot. Panicle length and flag leaf length were measured in the middle of each plot. Grain yield was harvested from 4 m² from the middle of the plot with 14 % humidity. Internodes number and length of 4th internodes were numbered from 12 hills in middle of each plot. Diameters of 4th inter-nodes were measured by Calliper from 12 stems in 4 hills per plot (Islam *et al*., 2007). Bending moment of 4th internodes was measured from 12 stems in 4 hills per plot. Bending moment of 4th internode (g cm) = length of the plant from the lowest node of 4th internode up to the panicle × the wet weight of the same part (Islam *et al*., 2007). Data analyzed by MSTAT-C statistical software and averages comparison were calculated by Duncan's multiple range tests in a 5% probability level.

RESULTS AND DISCUSSION

Plant height had significant effect under nitrogen treatment in 5 % probability level and under phosphorus treatment 1 % probability level (Table 3). Minimum plant height (105.4 cm) was noted for control (0 kg N ha^{-1}) and maximum of that (109.3 and 111.3 cm) was for 50 and 100 kg N h^{-1}. Plant height increased 11.54% by phosphorus application. Maximum plant height (116 cm) was obtained for 225 kg P ha^{-1}, and minimum of that (104 cm) was for control (Table 4). The most plant height (119.7 cm) was observed at interaction of 50 kg N ha^{-1} × 225 kg P ha^{-1}, and the least plant height (100 cm) had been obtained at interaction of 0 kg N ha^{-1} × 0 kg P ha^{-1} (Table 5). Islam *et al.,* (2007) found that high lodging resistance of hybrids was not associated with a short plant height and this is consistent with the results of Ookawaand Ishihara (1992), who reported that plant height was not necessarily the most important factor in determining lodging resistance. Islam *et al.,* (2007) suggests that the height of rice plants can be increased up to 120 cm without a lodging problem as long as they have high breaking resistance and dry weight per unit length in the lower internodes. Mobasser *et al.,* (2005)

Table 5. Interaction of of nitrogen levels in heading stage and phosphorus rates on lodging related traits of rice at Sari in 2011

Interaction	Plant height (cm)	Stem length (cm)	Panicle length (cm)	Flag leaf length (cm)	Fourth internode length (cm)
N_1P_1	100.0 d	80.00 ef	23.33 ab	19.00 d	26.67 ab
N_1P_2	103.3 cd	83.00 c-f	23.67 ab	21.67 cd	30.00 a
N_1P_3	107.3 cd	84.33 b-e	26.33 ab	22.00 bcd	29.67 a
N_1P_4	111.0 bc	87.67 a-d	26.67 ab	22.67 a-d	30.00 a
N_2P_1	103.3 cd	76.67 f	26.67 ab	22.00 bcd	23.00 ab
N_2P_2	105.0 cd	80.33 ef	24.67 ab	23.67 abc	28.00 ab
N_2P_3	109.3 bc	82.00 def	27.33 ab	26.33 a	26.67 ab
N_2P_4	119.7 a	90.67 ab	29.00 a	26.00 ab	27.33 ab
N_3P_1	108.7 cd	85.00 b-e	23.67 ab	23.33 abc	22.33 b
N_3P_2	107.3 cd	87.67 a-d	23.00 ab	22.67 a-d	29.00 ab
N_3P_3	111.7 abc	89.67 abc	22.00 b	23.33 abc	30.00 a
N_3P_4	117.3 ab	92.33 a	21.67 b	24.33 abc	30.00 a

Values within a column followed by same letter are not significantly different at Duncan ($P \leq 0.05$).
N_1, N_2, and N_3: Nitrogen levels in heading stage including 0, 500 50 and 100 kg ha^{-1}, respectively.
P_1, P_2, P_3, and P_4: Phosphorus rates including 0, 75, 150, and 225 kg ha-1, respectively.

Table 6. Mean square of nitrogen levels in heading stage and phosphorus rates on bending moment, tiller number and quantity yield of rice at Sari in 2011

S.O.V.	DF	Fourth internode bending moment	Total tiller number per hill	Fertile tiller number per hill	Grain yield	Straw yield
Replication	2	63277.00**	28.61**	21.33*	36237.58**	142788.03**
Nitrogen (N)	2	138032.33**	34.03**	59.25**	31931.08**	47662.03**
Phosphorus (P)	3	73378.00**	0.67	0.55	2414.00	1710.11
N×P	6	7175.11	1.47	1.21	860.53	6834.58
E	22	8495.21	3.47	4.12	1910.34	8180.30
C.V. (%)	-	5.43	17.83	22.77	8.23	8.59

** and * significant in 1 and 5% level, respectively.

Table 7. Mean comparison of nitrogen levels in heading stage and phosphorus rates on bending moment, tiller number and quantity yield of rice at Sari in 2011

Treatment	Fourth internode bending moment (g cm)	Total tiller number per hill	Fertile tiller number per hill	Grain yield (g.m^2)	Straw yield (g.m^2)
Nitrogen levels					
0	1777 a	8.50 b	6.42 b	508.0 b	1079.0 a
50 kg ha^{-1}	1742 a	11.42 a	10.67 a	494.9 b	981.7 b
100 kg ha^{-1}	1577 b	11.42 a	9.67 a	590.1 a	1100.0 a
Phosphorus rates					
0	1606 c	10.22 a	9.11 a	551.2 a	1047 a
75 kg ha^{-1}	1655 bc	10.56 a	9.00 a	535.7 a	1038 a
150 kg ha^{-1}	1718 b	10.78 a	9.00 a	524.2 a	1070 a
225 kg ha^{-1}	1815 a	10.22 a	8.56 a	512.9 a	1058 a

Values within a column followed by same letter are not significantly different at Duncan ($P \leq 0.05$).

Table 8. Interaction of of nitrogen levels in heading stage and phosphorus rates on bending moment, tiller number and quantity yield of rice at Sari in 2011

Interaction	Fourth internode bending moment (g cm)	Total tiller number per hill	Fertile tiller number per hill	Grain yield (g.m^2)	Straw yield (g.m^2)
N_1P_1	1705 b-e	8.67 bc	7.00 bcd	513.3 cd	1027.0 abc
N_1P_2	1740 bcd	8.67 bc	6.33 cd	499.3 cd	1085.0 abc
N_1P_3	1797 abc	8.33 c	6.00 d	525.7 bcd	1094.0 abc
N_1P_4	1867 ab	8.33 c	6.33 cd	493.7 cd	1108.0 ab
N_2P_1	1598 def	11.00 abc	10.33 ab	529.0 bcd	1048.0 abc
N_2P_2	1665 c-f	11.67 abc	11.00 a	505.7 cd	952.3 bc
N_2P_3	1774 abc	12.67 a	11.67 a	477.7 d	997.0 abc
N_2P_4	1932 a	10.33 abc	9.67 a-d	467.3 d	929.7 c
N_3P_1	1515 f	11.00 abc	10.00 abc	611.3 a	1065.0 abc
N_3P_2	1559 ef	11.33 abc	9.67 a-d	602.0 ab	1078.0 abc
N_3P_3	1584 def	11.33 abc	9.33 a-d	69.3 abc	1119.0 ab
N_3P_4	1648 c-f	12.00 ab	9.67 a-d	577.7 abc	1137.0 a

Values within a column followed by same letter are not significantly different at Duncan ($P \leq 0.05$).
N_1, N_2, and N_3: Nitrogen levels in heading stage including 0, 500 50 and 100 kg ha^{-1}, respectively.
P_1, P_2, P_3, and P_4: Phosphorus rates including 0, 75, 150, and 225 kg ha-1, respectively.

found that statistically the panicle length showed a significant difference at the 5 % probability level by interaction of year × nitrogen rate × nitrogen splitting.

Stem length had significant effect under nitrogen treatment and under phosphorus treatment 1 % probability level (Table 3). Maximum stem length (137.1 cm) was observed for 100 kg h^{-1} nitrogen and minimum of that (88.67 cm) was for 100 kg N ha^{-1}, and minimum stem length (83.75 and 82.42 cm) was obtained for control and 50 kg N ha^{-1}. Stem length increased 11.99 % by phosphorus application. Maximum stem length (90.22 cm) was obtained for 225 kg P ha^{-1}, and minimum of that (80.56 cm) was for 225 kg P h^{-1} (Table 4). The most stem length (92.33 cm) was observed at interaction of 100 kg N ha^{-1} × 225 kg P ha^{-1}, and the least stem length (76.67 cm) had been obtained at interaction of 50 kg N ha^{-1} × 0 kg P ha^{-1} (Table 5). Since stem lodging usually occurs at the lower internodes, only the diameter of N_4 was measured near the lower node of N_4 after removing the leaf sheath (Islam *et al.,* 2007).

Panicle length had significant effect under nitrogen treatment in 5 % probability level (Table 3). The maximum panicle length (26.92 cm) was observed for 50 kg h^{-1} nitrogen and minimum of that (22.58 cm) was for 100 kg N ha^{-1}. Most panicle length (29 cm) was obtained for interaction of 50 kg N ha^{-1} × 225 kg P ha^{-1}, and least of that (22 and 21.67 cm) was observed at interaction of 100 kg N ha^{-1} and 150 and 225 kg P ha^{-1} (Table 5). Panicle length affects in grain yield by more transport of photosynthesis material (Dobermann *et al.,* 2002).

Flag leaf length had significant effect under nitrogen treatment in 1 % probability level and under phosphorus treatment 5 % probability level (Table 3). Maximum flag leaf length (25.40 and 23.42 cm) was observed for 50 and 100 kg h^{-1} nitrogen and minimum of that (21.33 cm) was for control. Most of flag leaf length (23.89 and 24.33 cm) was obtained for 150 and 225 kg P ha^{-1}, and least flag leaf length (21.44 cm) was obtained in control treatment (Table 4). The most flag leaf length (26.33 cm) was observed at interaction of 50 kg N ha^{-1} × 150 kg P ha^{-1}, and the least flag leaf length (19 cm) had been obtained at interaction of 0 kg N ha^{-1} × 0 kg P ha^{-1} (Table 5). Pantuwan *et al.* (2002) stated that grain yield had a positive correlation and significant with flag leaf length.

Fourth inter-node length had significant effect under phosphorus treatment in 5 % probability level (Table 3). The Maximum fourth inter-node length (29, 28.78 and 29.11 cm) was obtained for 75, 150 and 225 kg P ha^{-1}, and minimum of that (24 cm) was for control (Table 4). Minimum fourth inter-node length (22.33 cm) was obtained under interaction 100 kg N ha^{-1} × 0 kg P ha^{-1} (Table 5). Yoshida (1981) stated that inter-node length decreased by less than 40 kg h^{-1} nitrogen application. Fourth inter-nodes length are important for morphological characteristics related to lodging, because the most lodging were happened in this two areas, on the other hand fourth inter-nodes length have positive correlation with lodging index (Islam *et al.*, 2007).

Fourth inter-node bending moment had significant effect under nitrogen and phosphorus treatment in 5 % probability level (Table 3). Maximum bending moment of fourth inter-node (1777 and 1742 g cm) was obtained for control and 50 kg N ha^{-1}, and minimum of that (1577 g cm) was for 100 kg h^{-1} nitrogen application. Fourth inter-node bending moment increased 13.01 % by phosphorus application. Most bending moment (1815 g cm) was observed for 225 kg P ha^{-1}, and least bending moment (1606 g cm) was observed in control treatment (Table 4). Highest fourth inter-node ending moment (1932 g cm) had observed at interaction 50 kg N ha-1 × 225 kg P ha^{-1}, and lowest fourth inter-node bending moment (1515 g cm) had observed at interaction of 100 kg N ha^{-1} × 0 kg N ha^{-1} (Table 5). Islam *et al.,* (2007) found that the diameter of N_4 was significantly correlated with bending moment and breaking resistance of lower internodes.

Total tiller number per hill had significant effect under nitrogen treatment in 1 % probability level (Table 3). Total tiller increased 34.35 % by nitrogen application. Maximum tiller number (11.42 tillers) was noted for 50 and 100 kg nitrogen application and minimum of that (8.5 tillers) was for control (Table 4). The most tiller number (12.67 tillers) had obtained at interaction of 50 kg N ha^{-1} × 150 kg P ha^{-1}, and least tiller number (8.33 tillers) was observed at interaction of 0 kg N ha^{-1} × 150 and 225 kg P ha^{-1} (Table 5). Mobasser *et al.,* (2005) found that nitrogen application on 50 % during first tillering stage induced an increase the number tiller per hill and also the number tiller per hill was statistically affected by nitrogen splitting. Also, Ladha *et al.,* (1998) stated that the use of nitrogen induces an increase the number tiller in rice.

Fertile tiller number per hill had significant effect under nitrogen treatment in 1 % probability level (Table 3). Most fertile tiller number (10.67 and 9.67 number) was noted for 50 and 100 kg h^{-1} nitrogen application and least of that (6.42 tillers) was for control (Table 4). The most fertile tiller number (11 and 11.67 tillers) had obtained at interaction of 50 kg N ha^{-1} × 75 and 150 kg P ha^{-1}, and least tiller number (6 tillers) was observed at interaction of 0 kg N ha^{-1} × 150 kg P ha^{-1} (Table 5). The study of Sahrawat *et al.,* (1995) was based on varied levels of P using the same level of N, it was not possible to detect the significant interactions between the two nutrients when levels of both nutrients were varied.

Grain yield had significant effect under nitrogen treatment in 1 % probability level (Table 3). Maximum grain yield (590.1 g m^2) was observed for 100 kg h^{-1} nitrogen application and minimum of that (508 and 494.9 g m^2) was for control and 50 kg N ha^{-1} (Table 4). The highest grain yield (611.3 g m^2) was produced at interaction of 100 kg N ha^{-1} × 0 kg P ha^{-1}, and the lowest grain yield (477.7 and 467.3 g m^2) was produced at interaction of 50 kg N ha^{-1} × 150 and 225 kg P ha^{-1} (Table 5). Pantuwan *et al.* (2002) reported that grain yield had positive correlation with flag leaf length. Maximum grain yield was obtained by 69 kg h^{-1} nitrogen and nitrogen contributing in three times (transplanting time, panicle initiation and heading time) (Mobasser *et al.,* 2005). Grain yield increased by 120 kg h^{-1} nitrogen contributing in three times (transplanting time, tillering time and panicle initiation) (Singh *et al.,* 2002). Furthermore, the N fertilizer rate that produced maximum grain yield also produced the highest head rice (whole milled rice) yield (Bond and Bollich, 2007). Although earlier studies had reported that P-deficiency was more important than N-deficiency in the humid forest agro-ecosystem of West Africa (Sahrawat, 2000).

Straw yield had significant effect under nitrogen treatment in 1 % probability level (Table 3). Maximum straw yield (1079 1100 g m^2) was observed for control and 100 kg nitrogen application and minimum of that (9817 g m^2) was for 50 kg h^{-1} nitrogen application (Table 4). The most straw yield (1137 g m^2) was produced at interaction of 100 kg N ha^{-1} × 225 kg P ha^{-1}, and least of that (929.7 g m^2) had obtained for interaction of 50 kg N ha^{-1} × 225 kg P ha^{-1} (Table 5).

CONCLUSIONS

According to results of this study, plant height, stem length, panicle length, total tiller number, fertile tiller number and grain yield were increased by increasing the nitrogen fertilizer. Application of phosphorus increased lodging-related traits such as plant height, stem length, panicle length, fourth inter-node length and fourth inter-node bending moment. Therefore, application of 100 kg N in heading stage due to highest grain yield, and rice plant was the best treatment, because of deficit phosphorus in soil, showed the best response to 225 kg P ha^{-1}.

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