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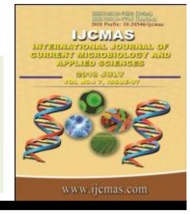

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Effect of Varying Levels of Nitrogen and Planting Geometry on High Yielding Boro Rice in New Alluvial Zone of West Bengal

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A B S T R A C T

A field experiment was conducted at Regional Research Sub Station (RRSS), New Alluvial Zone, Chakdah, Nadia, West Bengal during boro season (2013-2014) to study the effect of varying levels of nitrogen and planting geometry on high yielding boro rice. The experiment was laid out in factorial randomized block design (FRBD) replicated thrice. The treatments comprised of 4 nitrogen levels (0, 100, 120 and 140 kg N ha^{-1}) and three planting geometry (15 cm x 15 cm, 20 cm x 15 cm and 20 cm x 20 cm). The treatment receiving 140 N kg ha^{-1} gave the highest growth attributes such as plant height (101.81cm), number of tiller m^{-2} (444.08) and dry matter accumulation (DMA) (815.58 g m^{-2}) which was statistically at par with 120 N kg ha^{-1}. Maximum plant height (100.03 cm) was obtained at 20 cm x 20 cm. However, maximum number of tillers $hill^{-1}$ (473.62) and DMA (847.33 g m^{-2}) were observed at 15 cm x 15 cm. Yield attributes like number of panicles m^{-2} (304.00), number of filled grains $panicle^{-1}$ (124.52) and panicle length (24.53 cm) were found maximum with nitrogen level of 120 kg ha^{-1}. Grain yield increased gradually with increasing level of nitrogen up to 120 kg N ha^{-1} (4.54 t ha^{-1}) and the plant spacing of 20 cm x 15 cm gave the highest grain yield (4.16 t ha^{-1}).

Introduction

Rice (*Oryza sativa*) is an important cereal crop in the developing world and accounts for the dietary energy requirements for almost half of the world population. It is primarily a high energy or high caloric food containing around 78.2% carbohydrate, 6.8% protein, 0.5% fat and 0.6% mineral. At present, rice is cultivated in around 113 countries, which is a staple food for over half of the world's population (Prasad *et al.*, 2012). Rice (*Oryza sativa* L.) is the principal crop of India cultivated in an area of 44 million ha annually with a production of 103 mt, with an average productivity of 2.3 t/ha (Parthipan *et al.*, 2013). Boro rice accounts for the 26 % of the gross rice growing areas of West Bengal and is grown under 100% irrigated condition with high yielding varieties mainly. It adds extra grain production for food security and brings about 48% increases in household income.

The soil and climate of India in states like West Bengal, Assam and Orissa are favorable for rice cultivation throughout the year but the yield of this crop is much below the potential level. The reasons are manifolds; some are varietal, some are technical and some are socio-economic in nature. The potential for increasing rice production strongly depends on the ability to integrate a better crop management practices for the different varieties into existing cultivation systems (Mikkelsen *et al*., 1995). Proper management practices are the most effective means for increasing yield of boro rice. This will require the adoption of new technology such as best management package, high yielding cultivar, higher input use etc. Besides, a careful study of the whole situation reveals that a number of other factors are also responsible for the low yield of rice. Out of these, agronomic management practices such as spacing and nitrogen application are two major factors influencing the growth and yield of rice. Optimum dose of nitrogen fertilization plays a vital role in growth and development and grain formation as a result of higher yield of rice plant. Excessive nitrogen fertilization encourages excessive vegetative growth which makes the plant susceptible to insect, pest and diseases, which ultimately reduces yield whereas less than optimum rate affects both yield and quality of rice to remarkable extent. So, it is essential to find out the optimum rate of nitrogen application for efficient utilization of this element by the plants for better yield. Optimum plant spacing ensures plants to grow properly both in their aerial and underground parts through utilization of solar radiation and nutrients, therefore proper manipulation of planting density may lead to increase in the economic yield of transplanted rice (Sampath *et al.,* 2017). Plant spacing determines the planting density or plant population in unit area thereby influencing the input use efficiency and yield of the crop. Spacing is a major non monetary input which plays a significant role in determining growth and yield of the crop. Keeping in view of the importance of optimum N supply to rice in relation to plant spacing for higher production, the present investigation was conducted to find out the optimum dose of nitrogen and spacing for boro rice variety Shatabdi (IET 4786).

Materials and Methods

Field experiment was conducted at Regional Research Sub-Station (RRSS), Chakdah, Nadia, New Alluvial Zone (NAZ) under Bidhan Chandra Krishi Viswavidyalaya, West Bengal at 23^{o} 5' N latitude and 83^{o} 5'E longitudes with an elevation of 9.75 m above the mean sea level. The soil of the experimental field was sandy clay loam in texture and belongs to the order Entisol. The experiment was conducted under irrigated shallow and medium land situation. The soil was medium in fertility with good drainage facility with 7.50 pH, 0.68% organic carbon, 0.052% total nitrogen, 16.90 kg ha^{-1} available phosphorus and 128.10 kg ha^{-1} available potassium respectively. The experiment was laid out in a factorial randomized block design (FRBD) in 3 replications. The treatments comprised of 4 levels of nitrogen (0, 100, 120 and 140 kg N ha^{-1}) and three planting geometry (15 cm x 15 cm, 20 cm x 15 cm and 20 cm x 20 cm). The cultivar used in the experiment was Shatabdi (IET 4786). Full dose of phosphorus and potassium in the form of single super phosphate (SSP) and muriate of potash (MOP) were applied as basal dose @ 60 kg ha^{-1} each respectively at final land preparation. Nitrogen in the form of urea was applied in 3 split doses, each one as basal application and as top dressing at active tillering stage and at panicle initiation stage. 25 days old seedlings were transplanted at a desired spacing of 15 cm x 15cm, 20 cm x 15 cm and 20 cm x 20 cm as per the treatments with 2-3 seedlings per hill at a depth of 3-4 cm. Irrigation was applied as and when required to maintain a shallow depth of submergence (3 to 5 cm) beginning with planting and continuing up to 2 weeks before harvesting of the crop. To control weeds, two hand weeding were given at 21 days after transplanting (DAT) and at 42 DAT. Growth attributes were recorded at 30 days interval. Yield and yield attributes were recorded at harvest. The data so obtained were subjected to statistical analysis by the analysis of variance method (Panse and Sukhatme, 1978) and the significant of different sources of variations were tested by error mean square by Fisher and Snedecor's F test at probability level 0.05.

Results and Discussion

Growth attributes

Plant height (cm)

The maximum plant height (101.81cm) was recorded in treatment N_3, receiving highest level of nitrogen of 140 kg ha^{-1} but statistically at par with N_2 (101.42 cm) and N_1 (100.26 cm) receiving 120 kg nitrogen ha^{-1} and 100 kg nitrogen ha^{-1} respectively where as lowest plant height (86.44 cm) was observed in control, N_0. The increased in plant height with increasing nitrogen might be attributed to the effect of nitrogen fertilizer which encourage and improve plant growth and accelerate cell division which was reflected in the increased plant height (Mohadesi *et al.,* 2011). Regarding the spacing, the maximum plant height (100.03 cm) was observed with wider spacing (S_3) of 20 cm x 20 cm followed by S_2 i.e. 20 cm x 15 cm (97.14 cm) but with no significant difference between them. The interaction effect did not show any significant difference although N_3S_3 recorded the maximum plant height (102.93 cm) whereas lowest plant height (80.0 cm) was recorded by N_0S_1 (Table 1). Maximum plant height was obtained with wider planting geometry (S_3) as compared to closer spacing of S_2 and S_1 because of creation of an optimum condition for light reception, water and nutrient consumption and less competition. This result is at par with the findings of Haque (2002) and Sridhara (2008).

Number of tillers m^{-2}

The maximum number of tillers m^{-2} (444.08) was recorded in treatment receiving highest dose of nitrogen (N_3) but statistically at par with N_2 (441.13) and lowest (234.44) was obtained in control, N_0. This was mainly due to more nitrogen availability at higher levels of nitrogen that provided proper nutrition to the crop thereby increased tillering. Higher dose of nitrogen might have helped in inducing vegetative growth leading to better interception of photosynthetically active radiation and greater photosynthesis by the crop. (Anil *et al.*, 2018). Among the three spacing, the maximum number of tillers m^{-2} (473.62) was attained in close spacing (S_1) followed by S_2 (381.29) which might be due to more number of hills per unit area (Table 1). These results are in line with those reported by Banerjee and Pal (2011) and Haque *et al.,* (2015). Among the interaction effects, N_3S_1 recorded maximum number of tillers m^{-2} (545.60) but was statistically at par with N_1S_1 (532.40) and N_2S_1 (541.93). The lowest number of tillers m^{-2} (195.00) was obtained in N_0S_3 which was lower than other interaction effects.

Dry matter accumulation/DMA (g m^{-2})

Similarly, N_3 recorded highest dry matter accumulation (815.58 g m^{-2}) followed by N_2 (807.51 g m^{-2}) and N_1 (783.81 g m^{-2}) but were statistically at par with each other. The higher total dry matter production was attributed to better plant growth which resulted in higher dry matter accumulation in leaves and stem at early growth stages and better translocation to ear heads during later stages (Prakasha *et al*., 2018). Significant differences were noticed among the different spacing i.e. S_1, S_2 and S_3 with respect to dry matter accumulation where close spacing of 15 cm × 15 cm (S_1) recorded highest dry matter (847.33 g m^{-2}) followed by wider spacing, S_2 (738.38 g m^{-2}) and S_3 (635.86 g m^{-2}) respectively. The N_3S_1 interaction recorded the highest dry matter accumulation (930.21 g m^{-2}) whereas the interaction N_0S_3 recorded the lowest (478.67 g m^{-2}) but there was no significant difference among the various interactions (Table 1). Close spacing recorded higher dry matter accumulation due to accommodation of more number of plants m^{-2}. Similar observation was also recorded by Mohadesi *et al.*, (2011).

Yield attributes

Number of panicles m^{-2}

Number of panicle m^{-2} significantly varied with varying levels of nitrogen. Maximum number of panicle m^{-2} was recorded with N_2 (304.00) followed by N_3 (303.18), N_1 (289.11) and lowest (159.75) was recorded in control (N_0) (Table 2). Mandal *et al.,* (1986) and Mahato *et al.,* (2007) too reported that higher levels of N application increased the number of panicles m^{-2} and thereafter decreased with fertilizers. Excessive nitrogen application decreased the effective number of panicles and grains per panicle and then eventually reduced rice production (Zhu *et al.,* 2017). Closer spacing of 15 cm x 15 cm (S_1) recorded significantly higher number of panicles m^{-2} (293.37) than wider spacing, S_2 (261.22) and S_3 (237.44) respectively. This might be due to higher plant population per unit area at close spacing. Mahato *et al.*, (2007) reported similar type of variation where closer spacing gave highest number of panicles m^{-2}. Interaction of nitrogen levels and planting geometry showed significant influence on number panicles per m^{-2}. N_2S_1 interaction recorded the maximum number of panicles m^{-2} (339.26) which was at par with N_3S_1 (338.22) whereas, the interaction N_0S_3 recorded the lowest panicles m^{-2} (150.83).

Number of filled grains panicle^{-1}

The highest number of filled grains panicle^{-1} (124.52) was obtained at 120 kg N ha^{-1} (N_2) which was statistically at par with N_3 (123.89) followed by N_1 (123.04). The lowest number of filled grains panicle^{-1} (81.44) was obtained from N_0 (Table 2). Nitrogen helps in proper filling of seeds which resulted in higher production of seeds and thus higher number of filled grains panicle^{-1}. More number of filled grains panicle^{-1} (115.29) were noted with 20 cm x 20 cm (S_3) plant spacing followed by closer spacing S_2 (113.34) and S_1 (111.03). This might be due to supply of more food materials, moisture and light for the plant under wider spacing and ultimately resulted in better environment for growth and development of the crop (Uddin *et al.*, 2011). The maximum number of filled grains panicle^{-1} (127.27) was obtained in the treatment combination of 120 kg N ha^{-1} and spacing 20 cm x 20 cm (N_2S_3) which was at par with N_2S_3 (126.17).

Panicle length (cm)

Panicle length significantly increased with the increase of nitrogen rate up to 120 kg N ha^{-1} and thereafter declined. Panicle length was highest in N_2 (24.53 cm) but was statistically at par with N_3 (24.41 cm) and N_1 (24.01 cm). Nitrogen takes part in panicle formation as well as panicle elongation and for this reason, panicle length increased with the increase of nitrogen fertilization up to 120 kg ha^{-1}. Plant spacing also had significant effect on panicle length. Longest panicle (24.21 cm) was observed with 20 cm x 20 cm spacing (S_3) but was statistically at par with 20 cm x 15 cm

(S_2) with 23.83 cm followed by S_1 (23.04 cm). The longest panicle (25.04 cm) was obtained from 20 cm x 20 cm with 120 kg N ha^{-1} (N_2S_3) which was higher than all other interaction effects. Plants grown at any plant spacing without N fertilizer produced shortest panicle (Table 2).

Panicle weight (g)

Varied level of nitrogen significantly differed the panicle weight and it ranges from 1.49 g to 2.06 g. Maximum panicle weight (2.06 g) was observed with the application of nitrogen 120 kg ha^{-1} (N_2) but was statistically at par with N_3 (2.03 g) followed by N_1 (1.92 g). The increase in yield-attributing characters of aerobic rice with the increase in N application might be owing to higher availability of N to plants leading to its higher uptake and translocation from vegetative parts to reproductive parts resulting in increased yield attributes (Nayak *et al*., 2016). Wider spacing S_3 show significantly higher panicle weight (1.92 g) followed by S_2 (1.89 g) and least weight was obtained in close spacing, S_1 (1.81 g). This might be due to competition of plants for light within the dense plants at closer hill spacing resulting in reduced panicle weight due to reduction in the rate of photosynthesis (Yadav, 2007). There was no significant difference among the interactions. However, wider spacing in combination with 120 kg N ha^{-1} recorded highest panicle weight (2.12 g) followed by N_2S_2 and N_3S_3 with a value of 2.08 g (Table 3).

Table.1 Effect of nitrogen and planting geometry on plant height (cm), number of tiller m^{-2} and dry matter accumulation of *boro* rice

Treatment	Plant height (cm)				Number of tillers m^{-2}				Dry matter accumulation (g m^{-2})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_0	80.00	85.33	94.00	86.44	274.56	233.75	195.00	234.44	620.40	566.50	478.67	555.19
N_1	99.33	100.37	101.07	100.26	532.40	423.28	334.33	430.00	912.76	770.00	668.67	783.81
N_2	100.70	101.43	102.13	101.42	541.93	432.30	349.17	441.13	925.96	806.30	690.28	807.51
N_3	101.07	101.43	102.93	101.81	545.60	435.82	350.83	444.08	930.21	810.70	705.83	815.58
Mean	95.28	97.14	100.03	97.48	473.62	381.29	307.33	387.41	847.33	738.38	635.86	740.52

	N	S	N X S	N	S	N X S	N	S	N X S
SEm(±)	1.486	1.287	2.574	4.103	3.553	7.106	12.615	10.925	21.850
CD (p=0.05)	4.358	3.774	NS	12.032	10.420	20.841	36.998	32.041	NS

N_0: Control, N_1: 100 kg ha^{-1}, N_2: 120 kg ha^{-1}, N_3: 140 kg ha^{-1}
S_1: 15 cm x 15 cm, S_2: 20 cm x 15cm, S_3: 20 cm x 20 cm

Table.2 Effect of nitrogen and planting geometry on number of panicles m^{-2}, number of filled grains $panicle^{-1}$ and panicle length of *boro* rice

Treatment	Number of panicles m^{-2}				Number of filled grains $panicle^{-1}$				Panicle length (cm)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_0	172.30	156.11	150.83	159.75	80.04	81.74	82.53	81.44	21.00	22.03	22.41	21.81
N_1	323.70	287.22	256.42	289.11	120.57	123.35	125.21	123.04	23.50	24.07	24.47	24.01
N_2	339.26	301.33	271.42	304.00	122.09	124.19	127.27	124.52	23.93	24.61	25.04	24.53
N_3	338.22	300.22	271.08	303.18	121.41	124.07	126.17	123.89	23.71	24.60	24.93	24.41
Mean	293.37	261.22	237.44	264.01	111.03	113.34	115.29	113.22	23.04	23.83	24.21	23.69

	N	S	N X S	N	S	N X S	N	S	N X S
SEm(±)	3.245	2.810	5.620	0.221	0.191	0.383	0.288	0.249	0.498
CD (p=0.05)	9.516	8.241	16.482	0.648	0.561	1.123	0.844	0.731	NS

Table.3 Effect of nitrogen and planting geometry on panicle weight, grain yield and straw yield of *boro* rice

Treatment	Panicle weight (g)				Grain yield (t ha^{-1})				Straw yield (t ha^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_0	1.35	1.55	1.57	1.49	2.67	2.75	2.83	2.75	3.78	3.84	3.93	3.85
N_1	1.93	1.93	1.91	1.92	4.20	4.52	4.10	4.27	5.37	5.58	5.30	5.42
N_2	1.99	2.08	2.12	2.06	4.45	4.87	4.30	4.54	5.59	5.93	5.48	5.67
N_3	1.99	2.01	2.08	2.03	4.33	4.49	4.17	4.33	5.53	5.58	5.39	5.50
Mean	1.81	1.89	2.01	1.88	3.91	4.16	3.85	3.97	5.07	5.23	5.03	5.11

	N	S	N X S	N	S	N X S	N	S	N X S
SEm(±)	0.031	0.027	0.054	0.096	0.083	0.166	0.068	0.059	0.118
CD (p=0.05)	0.091	0.079	NS	0.281	0.243	NS	0.199	0.173	NS

Yield (t ha^{-1})

The highest grain yield (4.54 t ha^{-1}) was obtained with 120 kg N ha^{-1} i.e. N_2 which was statistically at par with N_1 (4.27 t ha^{-1}) and N_3 (4.33 t ha^{-1}). It is due to better nutrient uptake leading to higher dry matter production and its translocation to sink leading to increased percent of filled grains and number of panicles m^{-2} (Mandal *et al*., 1986). Closer spacing of 20 cm x 15 cm produced significantly higher grain yield (4.16 t ha^{-1}) as compared to wider spacing 20 cm x 20 cm (3.85 t ha^{-1}). Very close spacing S_1 (15 cm x 15 cm) was undesirable for economic yield (Table 3). Further Wells and Faw (1978) reported that close spacing decrease light interception and CO_2 assimilation which in turn limit the rice yield. Namba (2003) reported that the increase in grain yield with optimum plant spacing might be attributed to increased number of tillers per unit area and filled grains per panicle after which plant growth slows down if it exceed the optimum level. Straw yield increased significantly up to 120 kg N ha^{-1}, thereafter decreased with increase in the nitrogen level.

Maximum straw yield (5.67 t ha^{-1}) was recorded with 120 kg ha^{-1} nitrogen (N_2) but was statistically at par with N_3 (5.50 t ha^{-1}) followed by N_1 (5.42 t ha^{-1}). This might be due to vigorous growth with increase in N level resulted in higher straw yield (Chopra and Chopra, 2004). Planting density greatly influenced the straw yield. The plant spacing of 20 cm x 15 cm (S_2) recorded highest straw yield (5.23 t ha^{-1}) as compared to closer spacing S_1 (5.07 t ha^{-1}) and wider spacing S_3 (5.07 t ha^{-1}) which might be due to reduce plant height and lesser plant population respectively. Similar observation was reported by Mahato *et al.,* (2006). However, the interaction effects were not significant. The increase in yield of hybrid rice due to N fertilization was attributed directly by the significant improvement of all the yield attributing traits *viz*. effective tiller m^{-2}, panicle length, filled grains panicle^{-1} and test weight (Banerjee and Pal, 2011).

Therefore, it can be concluded that treatment combination of 120 kg nitrogen ha^{-1} along with planting geometry of 20 cm x 15 cm could be recommended for cultivation of boro rice in New Alluvial Zone of West Bengal.

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