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Effect of nitrogen and boron on the yield and yield attributes of mustard

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ABSTRACT

The field experiment was conducted at the Agronomy Research Field of Patuakhali Science and Technology University (PSTU), Dumki, Patuakhali during the period from November, 2015 to February 2016 to find out the effect of nitrogen and boron on the yield and yield attributes of mustard. The experiment consisted of two factors. Factor-A: nitrogen (N) doses: 4 doses, N_0= without nitrogen, N_1= 60 kgha^{-1}, N_2=90 kgha^{-1}, N_3=120 kgha^{-1} and factor-B: boron (B) doses: 3 doses, B_0= without boron, B_1=1 kgha^{-1}, B_2= 2 kgha^{-1}. The experiment was laid out following RCBD with three replications. Data on different parameters related to seed yield and quality was recorded and statistically significant variation was found for nitrogen and boron. In terms of nitrogen fertilizer, 120 kg Nha^{-1} produced the highest in respect of plant height (67.67 cm), number of branches per plant (6.94), number of siliqua per plant (151.44), number of seeds per siliqua (24.90), 1000 seed weight (3.81 g), seed yield (1466.33 kgha^{-1}), stover yield (4577.96 kgha^{-1}), harvest index (24.23 %) and the lowest value found at control in most of the parameters. In case of boron fertilizer, plant height (59.75 cm), number of branches per plant (6.67), number of siliqua per plant (124.61), number of seeds per siliqua (22.51), 1000 seed weight (3.71 g), seed yield (1321.08 kgha^{-1}), stover yield (4378.55 kgha^{-1}), harvest index (22.97 %) were highest in boron @ 2 kg B/ha whereas the lowest results were found in control. Due to the interaction effect of nitrogen and boron in mustard, the plant height (72.00 cm) , number of branches per plant (7.39), number of siliqua per plant (157.00), number of seeds per siliqua (26.37), 1000 seed weight (3.86 g), seed yield (1569.00 kgha^{-1}), stover yield (4712.65 kgha^{-1}), harvest index (25.00 %) were highest in nitrogen @ 120 kg Nha^{-1} combined with boron @ 2 kg Bha^{-1} whereas the lowest value was found in nitrogen @ 0 kg Nha^{-1} combined with boron @ 0 kg Bha^{-1} in mustard.

INTRODUCTION

Mustard belongs to the genus *Brassica* under the family Cruciferae, it has three species that produce edible oil, namely *Brassica napus. B. campestris* and *B. juncea*. It is one of the most important oil seed crops throughout the world after soybean and groundnut (FAO, 2004) and one of the most important oilseed crops, source of vegetable oil, widely grown oilseed crops of Bangladesh occupying 0.532 million ha of land and the production was 0.596 million MT (metric ton) with the yield of 1.12 MT (metric ton) ha^{-1} in 2013-14 (AIS, 2015). This crop is currently ranked as the world's third important oil crop. Vegetable oils and fats (lipids) constitute an important component of human diet. Oils of plant origin constitute important component of human diet, ranking third after cereals and animal products and are nutritionally superior to animal oil (Singh, 2000). It is an important source of cooking oil in Bangladesh meeting one third of the edible oil requirement of the country (Ahmed, 2008). It is not only a high energy food but also a carrier of fat soluble vitamins (A, D, E and K) in the body. The National Nutrition Council (NNC) of Bangladesh reported that recommended dietary allowance (RDA) per capita per day should be 6 g of oil for a diet with 2700 K cal. On RDA basis, the edible oil need for 150 millions peoples are 0.39 million tons of oil equivalent to 0.82 million tons of oilseed (NNC, 1984). Mustard seeds contain 40-45 % oil and 20-25 % protein (Mondal and Wahhab, 2001).

The aroma and pungent flavor of mustard comes from the essential secondary metabolites sinalbin which is breakdown by myrosinase to produce isothiocyanate that inhibit weed seed germination

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which reduces the crop-weed competition in crop fields. The imbalance use of nutrients, inefficiency to select a suitable variety, lack of knowledge on climate change as well as suitable approaches which hinder the reduction of growth and seed yield of rapeseed in Bangladesh. Several researchers are still working for improving the seed yield and oil content of rapeseed with different management practices including proper use of fertilizers macro and micro or trace elements. Fertilizer is the depending source of nutrient that high yielding varieties of mustard are very responsive to fertilizers especially nitrogen (Gupta et al., 1972; Ali and Rahman, 1986 and Patel et al., 2004).

Bangladesh has been facing acute shortage of edible oil for the last several decades. Our internal production can meet only about 21% of our consumption. This quantity can meet only a fraction of the cooking oil, requirement for the country, the rest 79% is met from the imported sources (Begum et al., 2012). It needs to import oil and oilseeds to meet up the deficit every year spending huge foreign exchange. Due to insufficient oil production, a huge amount of foreign exchange involving over 160 million US Dollar is being spent every year for importing edible oils in Bangladesh (Rahman, 2002). The average ha^{-1} yield of mustard in this country is alarmingly very poor compared to that of advanced countries like Germany, France, UK and Canada producing 6,667 kg ha^{-1}, 5,070 kg ha^{-1}, 3,264 kg ha^{-1}, 3,076 kg ha^{-1}, respectively. The world average yield of rapeseed-mustard is 1,575 kg ha^{-1} (FAO, 2003).

Mustard is the principal oil crop in Bangladesh. Moreover, mustard oil cake is also used as a feed for cattle and fish and as a good manure. It also serves as an important raw material for industrial use such as in soaps, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals etc. Its oil is also used by the villagers for hair dressing and body massage before bath. Dry mustard straw is also used as fuel. Although it is an important crop but the cultivation of mustard has to compete with other grain crops and it has been shifted to marginal lands of poor productivity. With increasing population, the demand of edible oil is increasing day by day. It is, therefore, highly accepted that the production of edible oil should be increased considerably to fulfill the demand. The area under mustard is declining due to late harvesting of high yielding T. *aman* rice and increased cultivation of *boro* rice decrease in an area of 104,000 hectare and production 68,000 tons of mustard and rapeseed in last ten years (Anonymous, 2006). The major reasons for low yield of rapeseed-mustard in our country are due to lack of high yielding variety, appropriate population density and want of knowledge of sowing time and proper management practices etc.

Nitrogen has an important role in seed protein and physiological functions of the plant. It is possible to increase the yield per unite area by adopting improved cultural practices. Nitrogen (N) deficiency is widespread in Bangladesh; it is the most spectacular of all essential nutrients in its effect on plant growth and yield of this crop. The literature showed that nitrogen has significant effect on plant height, branches $plant^{-1}$, pods $plant^{-1}$ and other growth factors and yield of mustard (Mondal and Gaffer; 1983; Allen and Morgan; 1972). Nitrogen increases the vegetative growth and delayed maturity of plants. Excessive use of this element may produce too much of vegetative growth, thus fruit production may be impaired (Sheppeard and Bates, 1980; Singh et al.; 1972).

Boron (B) is directly or indirectly involved in several physiological and biochemical processes during plant growth. B deficiency causes reduction in cell enlargement in growing tissues. It's deficiency is responsible for creating male sterility and inducing floral abnormalities (Sharma, 2006). The seed yield also noticeably increased up to 1.5 kg B/ha and beyond that the increment of B level the seed yield decreased steadily with the irrespective of variety tested. Several physiological and biochemical functions of B in plants such as in water relation, ion absorption, IAA (Indole Acetic Acid) metabolism, sugar translocation, cell division, photosynthesis, fruit and seed development (Marschner 1995; Gupta 1993; Katyal and Singh 1983; Marcus-Wyner and Rains 1982).

Considering the above statement the present experiment was conducted to find out the effect of Nitrogen and Boron on mustard to observe the response of nitrogen and boron on yield and yield attributes of mustard.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Research Field of Patuakhali Science and Technology University (PSTU), Dumki, Patuakhali-8602. The field experiment was conducted during the period from November, 2015 to February 2016.

Characteristics of soil and climate

The experimental area belongs to the non-calcareous clay soil under Agro-ecological Zone of the Ganges Tidal Floodplain (UNDP and FAO, 1988). The soil of the experimental land belongs to the Barisal series of non-calcareous clay soil but they became more silty in the east and usually have a buried peat layer in the west under the Ganges Tidal Floodplain (AEZ-13). The land was clay loam in texture having a soil pH value of 6, moderate in organic matter content. Novermber 2015 to February 2016 with air temperature 15.50 to 30.40 ^{o}C with 80 to 87% relative humidity and 9 to 23 mm rainfall.

Planting materials

BARI sarisha-14 was used as plating material in this experiment. BARI sarisha-14 is a new high yielding varieties of mustard developed by the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. The seeds were collected from the BARI, Joydebpur, Gazipur.

Treatment of the experiment

The experiment consisted with two factors. Factor-A: Nitrogen (N) doses: 4 doses (N_0= Without Nitrogen, N_1= 60 kg/ha, N_2=90 kg/ha, N_3=120 kg/ha). Factor-B: Boron (B) doses: 3 doses, B_0= Without Boron, B_1=1 kg/ha, B_2= 2kg/ha. There were 12 (3 × 4) treatment combinations such as N_1B_0, N_2B_1, N_0B_0, N_1B_1, N_2B_0, N_3B_0, N_1B_2, N_3B_1, N_0B_1, N_2B_2, N_0B_2 & N_3B_2.

Experimental design and layout

The experiment was laid out following randomized complete block design with three replications. An area of 370 m^2 (43.5 m × 8.5 m) was divided into three equal blocks and each block was divided into 12 plots for distribution 12 treatment randomly. There were 12 unit plots with the size of the each unit plot was 3.0 m × 1.5 m.

Land preparation

The experimental plot was opened at 5th November, 2015, with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed for three times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil. Finally land was prepared at 14th November, 2015.

Application of manure and fertilizers

The total amount of urea and boron were applied as per treatments recommended and triple super phosphate, muriate of potash and borax were applied as recommended by FRG (Fertilizer Recommendation Guide), 2012. Bangladesh Agricultural Research Council (BARC) at the time of final land preparation. Urea was applied in three splits. First dose of urea fertilizer was applied at the time of final land preparation, second and third doses of urea fertilizer were applied at 20 and 45 days after sowing respectively.

Sowing of seeds in the field

The seeds of mustard were sown on November 17, 2015 in solid rows in the furrows having a depth of 2-3 cm and as per treatment of plant density.

Intercultural operations

Thinning was done two times; first thinning was done at 8 day after seedling DAS (Days after seeding) and the second at 15 DAS to maintain optimum plant population in each plot as per the treatment of plant density. Irrigation was provided for three times at after seed sowing, 20 day before flowering and 50 days after sowing for pod development for all experimental plots equally. The crop field was weeded before providing irrigation. At early stage of growth few worms

(*Agrotis ipsilon*) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Ripcord 10 EC (cypermethrin; BASF Bangladesh Limited) was sprayed at the rate of 1 mm with 1 litre water for two times at 15 days interval after seedlings germination to control the insects.

Crop sampling and harvesting

Five plants from each treatment were randomly selected and marked with sample card. Plant height, branches plant^{-1} and leaf area index were recorded from selected plants at an interval of 10 days started from 30 DAS to 60 DAS and at harvest. Harvesting was done when 90% of the siliqua became brown in color. The matured pods were collected by hand picking from each plot.

Data collection

The plant height was measured at 30, 45, 50 and 60 DAS and at harvest with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm. The number of branches plant^{-1} was counted at 30, 45, 50 and 60 DAS and at harvest from selected plants. The average number of branches plant^{-1} was determined and recorded. Numbers of total siliqua of selected plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The number of seeds siliqua^{-1} was recorded from randomly selected 10 siliqua at the time of harvest. Data were recorded as the average and express in siliqua^{-1}. One thousand cleaned, dried seeds of mustard were counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g). The seeds collected from 4.5 (3 m ×1.5 m) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}. The stover collected from 4.5 (3 m ×1.5 m) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

Harvest index (HI) was calculated from the seed and stover yield of mustard and expressed in percentage.

$$HI = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the effect of variety and plant density on seed yield and seed quality of mustard. The mean values of all the characters were calculated and analysis of variance was performed by R 3.3.1 with software package Agricolae. The significance of the difference among the treatment means was separated by Honestly Significant Difference (HSD) at 0.05 level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield and yield contributing character

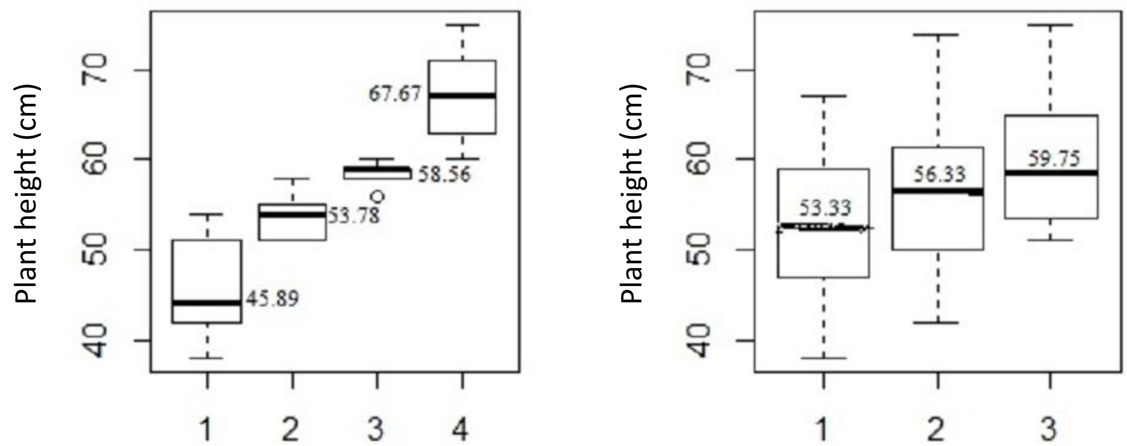
Plant height

The effect of nitrogen showed a statistically significant variation for plant height of mustard under the present trial. The tallest plant (67.67 cm) was recorded from N_3 treatment comprising of 120 kg N/ha (Figure 1). The plant height increased significantly with increasing the levels of N. Ali et al. (1990), Mondal and Gaffer (1983), Gaffer and Razzaque (1983), Asaduzzaman and Shamsuddin (1986) also reported the similar results from their experiment. They reported that different levels of nitrogen significantly increased plant height of mustard.

Table 1
Effect of nitrogen on yield contributing characters of mustard.

Nitrogen levels	Number of branches per plant (no.)	Number of siliqua per plant (no.)	Number of seeds per siliqua (no.)
N_0	4.91 c	73.30 d	16.92 d
N_1	6.48 b	104.11 c	20.67 c
N_2	6.58 b	144.11 b	22.99 b
N_3	6.94 a	151.44 a	24.90 a
$LSD_{(0.05)}$	0.11	1.38	0.20

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Where, N_0= 0 kg N/ha, N_1= 60 kg N/ha, N_2= 90 kg N/ha and N_3= 120 kg N/ha.



a. Doses of N, Where 1= 0 kgha^{-1}, 2= 60 kg ha^{-1}, 3= 90 kg ha^{-1} and 4= 120 kg ha^{-}

b. Doses of B, Where 1= 0 kg ha^{-1}, 2= 1 kg ha^{-1}, and 3= 2 kg ha^{-1}

Figure 1
Box plot showing effect of N (a) and B (b) on plant height of mustard.

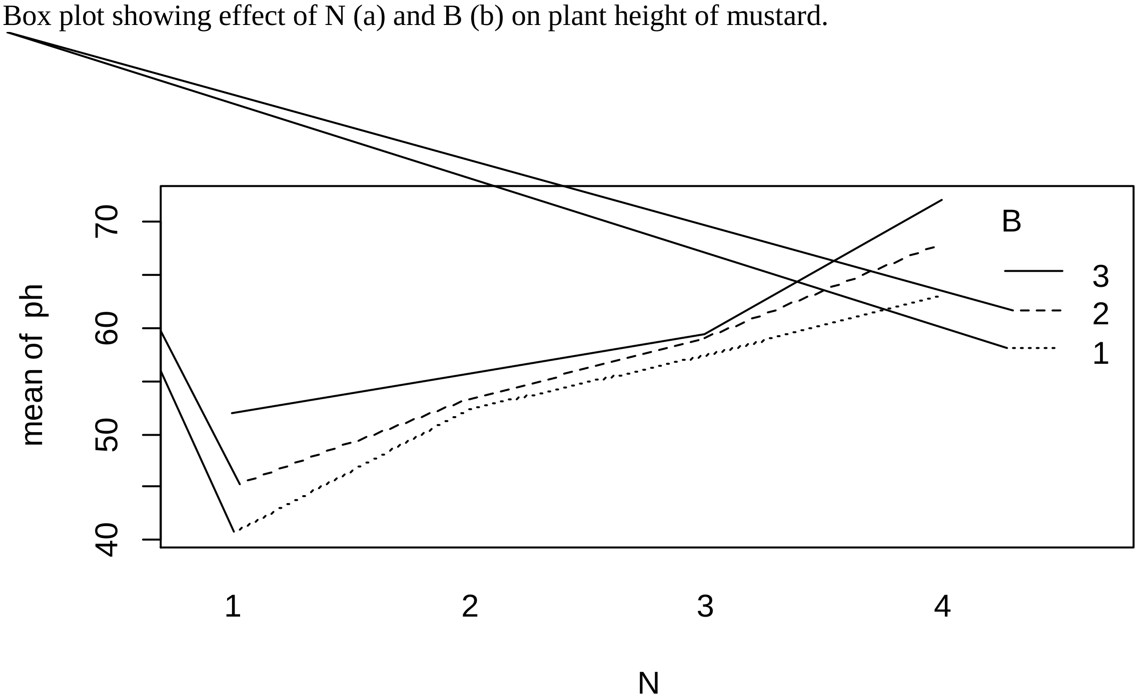


Figure 2
Interaction effect of N and B on plant height of mustard. Where N_1= 0 kg N/ha, N_2= 60 kg N/ha, N_3= 90 kg N/ha and N_4= 120 kg N/ha, and B_1= 0 kg B/ha, B_2= 1 kg B/ha and B_3= 2 kg B/ha.

Table 2
Effect of boron on yield contributing characters of mustard.

Boron levels	Number of branches per plant (no.)	Number of siliqua per plant (no.)	Number of seeds per siliqua (no.)
B_0	5.82 c	108.87 c	20.16 c
B_1	6.19 b	121.25 b	21.44 b
B_2	6.67 a	124.61 a	22.51 a
$LSD_{(0.05)}$	0.10	1.20	0.17

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Where, B_0= 0 kg B/ha, B_1= 1 kg B/ha and B_2= 2 kg B/ha.

Table 3
Interaction effect of nitrogen and boron on the yield contributing characters of mustard.

Nitrogen x Boron	Number of branches per plant	Number of siliqua per plant	Number of seeds per siliqua
N_0B_0	4.74 g	71.14 i	16.13 j
N_0B_1	4.80 g	72.67 i	16.50 i
N_0B_2	5.20 f	76.10 h	18.13 h
N_1B_0	6.10 e	96.00 g	20.73 fg
N_1B_1	6.43 c	106.67 f	20.50 g
N_1B_2	6.90 b	109.67 e	20.77 fg
N_2B_0	6.23 cde	126.00 d	20.93 f
N_2B_1	6.31 cd	150.67 b	23.27 d
N_2B_2	7.20 a	155.67 a	24.77 c
N_3B_0	6.20 de	142.33 c	22.83 e
N_3B_1	7.23 a	155.00 a	25.50 b
N_3B_2	7.39 a	157.00 a	26.37 a
$LSD_{(0.05)}$	0.22	2.67	0.38
CV (%)	1.83	1.20	0.94

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Where N_1= 0 kg N/ha, N_2= 60 kg N/ha, N_3= 90 kg N/ha and N_4= 120 kg N/ha, and B_1= 0 kg B/ha, B_2= 1 kg B/ha and B_3= 2 kg B/ha.

Different level of boron exhibited statistically significant differences for plant height (Figure 1, 2). With increasing the doses of B, the plant height increased significantly upto the highest dose 2 kg B/ha (S_2) and the maximum plant height was 59.75 cm. On the other hand the shortest plant height (53.33 cm) was recorded from S_0 treatment i.e. control condition under the present trial. Insignificant interaction effect was recorded between nitrogen and boron in consideration of plant height under the present experiment (Table 2). Numerically the tallest plant (72.0 cm) was recorded from the treatment combination N_3B_2 comprising of 120 kg N/ha + 2 kg B/ha, while the shortest plant (40.67 cm) was recorded from N_0B_0 i.e. no nitrogen+no boron (Figure 2, Table 3).

Branches per plant

A statistically significant variation for branches per plant of mustard was recorded for the effect of nitrogen (Table 1). The number of branches per plant increased significantly with increasing N levels upto the treatment N_3 comprising of 120 kg N and the maximum number of branches per plant (6.94) was obtained with this treatment (Table 1 and Figure 1). Mondal and Gaffer (1983), Gaffer and Razzaque (1983) also reported the similar results from their experiment. They reported that 120 kg N/ha significantly increased branches per plant of mustard. Number of branches per plant for different levels of boron gave significant variation (Table 2). The highest significant increase in number of branches per plant (6.67) was recorded from B_2 treatment containing 2 kg B/ha. On the other hand the minimum number of branches per plant (5.82) was observed from the B_0 treatment. Interaction effect between nitrogen and boron showed a significant difference for the number of branches per plant under the present experiment (Table 1). The maximum number of branches per plant (7.39) was observed from the treatment combination N_3S_2 having 120 kg N/ha + 2 kg B/ha, which was statistically identical to N_3B_1 (7.23) and N_2B_2 (7.20) (Table 3).

Number of Siliqua per plant

Number of siliqua per plant of mustard showed a statistically significant variation for different nitrogen levels under the present trial (Table 1). The number of siliquae per plant enhanced with increasing the doses of N and the greatest significant number was obtained with N_3 (120 kg N/ha) (Table 1). Mondal and Gaffer (1983), Gaffer and Razzaque (1983) also reported the similar findings from their experiment. They reported that different levels of nitrogen significantly increased siliqua per plant of mustard ensuring proper growth of plant. Sharawat et al. (2002) recorded maximum number of siliquae/plant with 120 kg N/ha. These results indicated that higher dose of nitrogen favored higher number of siliqua formation in mustard. Different level of boron showed statistically significant differences for siliqua per plant (Table 2). The maximum number of siliqua per plant (124.61) was observed from B_2 treatment comprising of 2 kg B/ha (Table 2). On the other hand the minimum number of siliqua per plant (108.87) was recorded from the B_0 treatment. Nitrogen and boron showed a significant interaction effect for number of siliqua per plant (Table 3). The maximum number of siliqua per plant (157) was recorded from the treatment combination N_3B_2 (120 kg N/ha + 2 kg B/ha), which was statistically identical to N_2B_2 (155.67) and N_3B_1 (155.00) (Table 3).

Seeds per siliqua

Effect of nitrogen showed a statistically significant variation for seeds per siliqua of mustard (Table 1). The number of seeds per siliqua increased with increasing N levels and maximum significant increase was found with the treatment N_3 (120kg N/ha) (Table 1). Mondal and Gaffer (1983), Gaffer and Razzaque (1983) also reported the similar results from their experiment. They reported that different levels of nitrogen significantly increased seed per siliqua of mustard. Similar result was also reported by Sharawat et al. (2002), Sen et al. (1977) and Allen and Morgan (1972). Statistically significant variation was recorded for different level of boron used in this experiment for seed per siliqua (Table 2). The number of seed per siliqua increased with increasing levels of B and the maximum number of seed per siliqua (22.51) was recorded from B_2 treatment as application of 2 kg B/ha (Table 5). These results are in conformity with those of Islam and Sarker (1993), Dutta and Uddin (1983) who have observed increased number of siliquae/plant of mustard by increasing rate of boron. A significant interaction effect was also recorded between nitrogen and boron in consideration of number of seed per siliqua under the present experiment (Table 3). The maximum number of seed per siliqua (26.37) was recorded from the treatment combination N_3B_2 comprising of 120 kg N/ha + 2 kg B/ha (Table 3).

1000 seed weight

Nitrogen showed statistically significant differences for 1000 seed weight of mustard under the present study (Table 4). The weight of 1000 seed increased with increasing levels of N upto N_3 (120 kg N/ha) (Table 4). The highest weight of 1000 of seeds (3.81 g) was recorded from N_3 treatment. Mondal and Gaffer (1983), Gaffer and Razzaque (1983), Sharawat et al. (2002), Mudholkar and Ahlawat (1981) also reported the similar results from their experiment. Different levels of boron exhibited statistically significant variation for 1000 seed weight (Table 2). It increased significantly with higher levels of boron with the highest (3.71 g) at B_2 treatment comprising of 2 kg boron/ha (Table 8). Interaction effect of nitrogen and boron showed insignificant variation for 1000 seed weight under the present experiment (Table 5).

Table 4
Effect of nitrogen on the yield contributing characters of mustard.

Nitrogen levels	1000 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
N_0	3.37 c	924.11 d	3840.46 d	19.40 d
N_1	3.56 b	1139.44 c	4107.13 c	21.69 c
N_2	3.75 a	1368.44 b	4399.95 b	23.67 b
N_3	3.81 a	1466.33 a	4577.96 a	24.23 a
$LSD_{(0.05)}$	0.07	3.66	101.27	0.38

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Where N_1= 0 kg N/ha, N_2= 60 kg N/ha, N_3= 90 kg N/ha and N_4= 120 kg N/ha, and B_1= 0 kg B/ha, B_2= 1 kg B/ha and B_3= 2 kg B/ha.

Table 5
Effect of boron on the yield contributing characters of mustard.

Boron levels	1000 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
B_0	3.52 c	1115.83 c	4066.05 c	21.41 c
B_1	3.64 b	1236.83 b	4249.53 b	22.37 b
B_2	3.71 a	1321.08 a	4378.55 a	22.97 a
$LSD_{(0.05)}$	0.06	3.17	87.71	0.33

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Where, B_0= 0 kg B/ha, B_1= 1 kg B/ha and B_2= 2 kg B/ha.

Seed yield

Application of nitrogen at different levels showed a statistically significant variation for seed yield per hectare of mustard under the present study (Table 4). With increasing the levels of nitrogen, the seed yield increased significantly. The highest seed yield (1466.33 kg/ha) was recorded from N_3 treatment comprising of 120 kg N/ha followed by 1368.44 kg/ha with N_2 and the lowest of (924.11 kg) was recorded from N_0 treatment (control) (Table 4). These results are in conformity with that of Tomer et al. (1996), Mondal and Gaffer (1983), Singh and Rathi (1984), Narang and Singh (1985) who have observed increased seed yield of mustard by increasing rate of nitrogen. Application of boron at different level showed statistically significant differences for seed yield per hectare (Table 5). The application of B favored the seed yield of mustard upto the highest level (2 kg B/ha). The highest seed yield (1321.08 kg/ha) was recorded from B_2 treatment comprising of 2 kg B/ha (Table 5). On the other hand the lowest seed yield (1115.83 kg/ha) was recorded from the B_0 treatment (control). Banueles et al. (1990) recorded significant differences for different level of boron application. Significant interaction effect was also recorded between nitrogen and boron for seed yield per hectare under the present experiment (Table 4, 5). The highest yield (1569 kg/ha) was recorded from the treatment combination N_3B_2 comprising of 120 kg N/ha + 2 kg B/ha and the lowest (880.33 kg/ha) was recorded from N_0B_0 where no nitrogen and boron was applied (Table 6).

Stover yield

Application of nitrogen at different levels showed a statistically significant variation for stover yield per hectare of mustard under the present study (Table 4). With increasing the levels of nitrogen, the stover yield increased significantly up to 120 kg N/ha. The highest stover yield (4577.96 kg/ha) was recorded from N_3 treatment comprising of 120 kg N/ha and the lowest stover yield (3840.46 kg) was recorded from N_0 treatment (control) (Table 4).

These results are in conformity with that of Tomer et al. (1996), Mondal and Gaffer (1983), Singh and Rathi (1984), Narang and Singh (1985) who have observed increased stover yield of mustard by increasing rate of nitrogen.

Table 6
Interaction effect of nitrogen and boron on yield contributing characters of mustard.

Nitrogen x Boron	1000 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
N_0B_0	3.25 g	880.33 l	3695.18 f	19.24 f
N_0B_1	3.32 fg	941.67 k	3901.53 e	19.45 f
N_0B_2	3.54 de	950.33 j	3924.68 de	19.50 f
N_1B_0	3.44 ef	1034.33 i	3955.36 de	20.73 e
N_1B_1	3.63 bcd	1149.67 h	4104.09 cd	21.88 d
N_1B_2	3.61 cd	1234.33 g	4261.93 bc	22.46 cd
N_2B_0	3.67 bcd	1257.00 f	4264.96 bc	22.76 bc
N_2B_1	3.75 ab	1317.67 d	4319.95 b	23.37 b
N_2B_2	3.83 a	1530.67 c	4614.94 a	24.93 a
N_3B_0	3.73 abc	1291.67 e	4348.69 b	22.90 bc
N_3B_1	3.84 a	1538.33 b	4672.55 a	24.78 a
N_3B_2	3.86 a	1569.00 a	4712.65 a	25.00 a
$LSD_{(0.05)}$	NS	7.07	NS	0.73
CV (%)	2.10	0.31	2.45	1.74

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. Where N_1= 0 kg N/ha, N_2= 60 kg N/ha, N_3= 90 kg N/ha and N_4= 120 kg N/ha, and B_1= 0 kg B/ha, B_2= 1 kg B/ha and B_3= 2 kg B/ha.

Application of boron at different levels showed statistically significant differences for stover yield per hectare (Table 6). The application of B favored the stover yield of mustard up to the highest level (2 kg B/ha). The highest stover yield (4378.55 kg/ha) was recorded from B_2 treatment comprising of 2 kg B/ha (Table 5). On the other hand the lowest stover yield (4066.05 kg/ha) was recorded from the B_0 treatment (control). Banueles et al. (1990) recorded significant differences for different level of boron application.

Insignificant interaction effect was recorded between nitrogen and boron for stover yield per hectare under the present experiment (Table 6). However, numerically highest stover yield (4712.65 kg/ha) was recorded from the treatment combination N_3B_2 comprisin4g of 120 kg N/ha + 2 kg B/ha and the lowest (3695.18 kg/ha) was recorded from N_0B_0 where no nitrogen and boron was applied (Table 6).

Harvest Index (%)

Harvest index found significant variation due to application of different levels of nitrogen (Table 4). With increasing the levels of nitrogen, the harvest index increased significantly up to 120 kg N/ha. The highest harvest index (24.23%) was recorded from N_3 treatment comprising of 120 kg N/ha and the lowest harvest index (19.40%) was recorded from N_0 treatment (control) (Table 4). These results are in conformity with that of Tomer et al. (1996), Mondal and Gaffer (1983), Singh and Rathi (1984), Narang and Singh (1985) who have observed highest harvest index of mustard at 120 kg N/ha.

Application of boron at different levels showed statistically significant differences for harvest index (Table 5). The application of B increased harvest index of mustard up to the highest level (2 kg B/ha). The highest harvest index (22.97%) was recorded from B_2 treatment comprising of 2 kg B/ha (Table 5). On the other hand the lowest harvest index (21.41%) was recorded from the B_0 treatment (control). Banueles et al. (1990) recorded significant differences for different level of boron application.

Significant interaction effect was also recorded between nitrogen and boron for harvest index under the present experiment (Table 6). The highest harvest index (25%) was recorded from the treatment combination N_3B_2 comprising of 120 kg N/ha + 2 kg B/ha, which again statistically identical to N_3B_1 (24.93%) and N_2B_2 (24.78%) and the lowest (19.24%) was recorded from N_0B_0 where no nitrogen and boron was applied, which again statistically identical to N_0B_1 (19.45%) and N_0B_2 (19.50%) (Table 6).

CONCLUSION

Nitrogen and boron are inevitable element in the production of oilseeds mustard which sustaining the productivity of mustard. The yield and yield contributing characters were highest in nitrogen @ 120 kg Nha^{-1} combined with boron @ 2 kg Bha^{-1}. Average increase in seed yield (1569 kg/ha) and harvest index of best treatment combination (N_3B_2)s suggesting its application in deficient areas is recommended to increase the productivity of mustard in the region.

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