# EFFECT OF DIFFERENT LEVELS OF NITROGEN AND BORON ON MORPHOLOGICAL CHARACTERS, YIELD AND SEED QUALITY OF RAPESEED (*Brassica campestris* L.)



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# *CERTIFICATE*

This is to certify that thesis entitled, "**EFFECT OF DIFFERENT LEVELS OF NITROGEN AND BORON ON MORPHOLOGICAL CHARACTERS, YIELD AND SEED QUALITY OF RAPESEED (*Brassica campestris* L.)** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRICULTURAL BOTANY**, embodies the result of a piece of bona fide research work carried out by **JESMIN ARA**, **Registration No. 06-01856** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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# DEDICATED TO
# MY
# BELOVED PARENTS

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*The Author*

# ABSTRACT

The experiment was conducted at the experimental Field of Sher-e-Bangla Agricultural University, Dhaka during the rabi season from November 2011 to February 2012 to evaluate the effect of different levels of nitrogen (N) and boron (B) on morphological characters, yield, oil content and germination percent of rapeseed (*Brassica campestris* L.). The experiment was factorial with two factors, factor A consisted of four different N levels *viz.* 0, 60, 120, 180 (kg/ha) and factor B consisted of three different levels of B(boron) *viz.* 0, 1, 2 (kg/ha). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed significant variation in almost every parameter. The plant height, leaves plant$^{-1}$, Primary and secondary branches plant-1, length of inflorescence at different days after sowing increased significantly with increasing rate of N. Interestingly, B did not show any significant variation on above parameters. As N, application of B significantly increased siliquae on main inflorescence, seed weight of 100 siliquae, seed weight plant-1, thousand seed weight, seed yield (t ha$^{-1}$) and harvest index as dose dependent manner. In addition, oil content of rapeseed showed varied significantly with both N and B independently, whereas N and B had no significant effect on germination percent of seed. These results indicated that N exhibited significant influence on morphological characters, yield, oil content and germination percent of seed whereas B showed differences on these parameters other than morphological characters. The interaction between different levels of N and B significantly influenced almost all morphological and yield contributing characters, seed yield and oil content of seed. The maximum value of morphological characters, yield contributing characters, seed yield and oil content of rapeseed was observed with the combined dose of 120 kg N/ha and 2 Kg B/ha ($N_2B_2$) whereas the lowest values were obtained from control i.e., $N_0B_0$ treatment combination. The maximum yield of seed per hectare (1.78 t) and the maximum oil content (42.96 %) was obtained from 120 kg N/ha with 2 Kg B/ha treatment combination. Separately, the combined use of N and B did not show any significant differences on germination percent of rapeseed. Based on the present results, it can be suggested that the combined doses of 120 kg N/ha with 2 kg B/ha ($N_2B_2$) is appropriate for higher yield and quality seed production of rapeseed cv. BARI Sarisha 14.

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## LIST OF ABBREVIATION AND ACRONYMS

| | | |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| BARI | = | Bangladesh Agricultural Research Institute |
| BBS | = | Bangladesh Bureau of Statistics |
| FAO | = | Food and Agricultural Organization |
| N | = | Nitrogen |
| B | = | Boron |
| *et al.* | = | And others |
| TSP | = | Triple Super Phosphate |
| MOP | = | Muirate of Potash |
| RCBD | = | Randomized Complete Block Design |
| DAS | = | Days after sowing |
| $ha^{-1}$ | = | Per hectare |
| g | = | gram (s) |
| kg | = | Kilogram |
| SAU | = | Sher-e-Bangla Agricultural University |
| SRDI | = | Soil Resources and Development Institute |
| wt | = | Weight |
| LSD | = | Least Significant Difference |
| $^0C$ | = | Degree Celsius |
| NS | = | Not significant |
| Max | = | Maximum |
| Min | = | Minimum |
| % | = | Percent |
| NPK | = | Nitrogen, Phosphorus and Potassium |
| CV% | = | Percentage of Coefficient of Variance |

# Chapter 1
# Introduction

# Chapter 1

# INTRODUCTION

Rapeseed (*Brassica campestris* L.) belongs to Brassicaceae family, which also includes cabbage, broccoli, cauliflower etc. It is originated from Asia Minor, but now is cultivating as a main commercial oil crop in Canada, China, Australia, and India including Bangladesh. It was reported that rapeseed is a popular crop in crop rotation, which increases cropping intensity since it enhances yields of wheat and barley, and breaks disease cycles in cereal grains.

Rapeseed seed oil is not only rich source of energy (about 9 k cal/g) but also rich in soluble vitamins A, D, E and K. 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). Using local ghani average 33 % oil may be extracted. Rapeseed seeds oil has traditionally been used to relieve muscle pain, rheuamtism and arthritic pain. Oil cake of rapeseed seed is a nutritious food item for cattle and fish and is also used as a good organic fertilizer. The aroma and pungent flavor of rapeseed comes from the essential secondary metabolites sinalbin which is breakdown by myrosinase to produce isothiocyanate that inhibit weed seed germination which reduces the crop-weed competition in crop fields.

Rapeseed is the major oilseed crop in Bangladesh covering about 70 % of the total production. The area and production of mustard of our country was about 0.481 million hectares and 0.536 million tons, respectively with an average yield of 1.11 t/ha during 2010-2011 (AIS, 2012). The present domestic edible oilseed production is 267 thousand tons, which meets only one third of national demand. Therefore, Bangladesh had to import a large quantity of edible oil every year at the cost of huge amount of foreign exchange worth BDT 11000 million during 2005-2006 fiscal year (BBS, 2006). 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. Meanwhile, the scientists have developed some varieties to increase the yield and quality of rapeseed. In addition, several researchers are still working for improving the seed yield of oil quality 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 rapeseed are very responsive to fertilizers especially nitrogen (Gupta et al., 1972; Ali and Rahman, 1986; Sharawat et al., 2002 and Patel et al., 2004). Nitrogen (N) is the key element for proper growth and yield of plants. It supports the plant with rapid growth, increasing seed and fruit production and yield of mustard (Sinha et al., 2003; Shukla et al. 2002a; Meena et al. 2002; Zhao et al. 1997 and Allen and Morgan 2009). Previous reports showed that N has significant effect on plant height, branches plant$^{-1}$, siliquae plant$^{-1}$ and other growth factors and yield of mustard (Allen and Morgan, 1972; Mondal and Gaffer, 1983). It was also reported that N significantly increased leaf area as well as rate of photosynthesis etc and the use of N either @250 kg/ha or @180 kg/ha produced higher seed yield (Hossain and Gaffer 1997; Singh and Prosad 2003). The oil content of mustard seed significantly decreased with increasing levels of N up to 80 kg/ha whereas oil content increased with increasing levels of phosphorus ( Premi and Kumar, 2004). In addition, the deficiency of N, causes stunted or slow growth, slender fibrous stems and the classic yellowing of the leaves which reduces the seed yield of crops including mustard (Ozer, 2003). Separately, excessive use of N increases the vegetative growth thus food production may be impaired and delayed maturity (Maini et al., 1959; Singh et al., 1972). These results suggest that the optimum dose of N for rapeseed plant growth, seed production, and oil content of rapeseed is needed to analyze.

Boron (B) is one of the six micronutrients or trace elements required by plants. It is known as a trace element because it is required in small quantities compared with elements such as phosphorus and sulphur. It 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). 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; Macus-Wyner and Rains 1982). 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. The seed yield of mustard increased from 15.5-68.55 % due to B application (Chatterjee et al., 1985). It is reported that the ranges between deficiency and toxicity of B are quite narrow and that an application of B can be extremely toxic to plants at concentrations only slightly above the optimum rate (Gupta et al., 1985). Crops differ in their sensitivity to B deficiency. *Brassica* crops in general have a high B requirement ( Mengel and Kirkby, 1987). Seed set failure is a major reason for lower yield of rabi crops and this problem can be attributed to B deficiency, as reported in mustard ( Rahman et al., 1993; Islam et al., 1997). The rapeseed oil content significantly increased with B up to 1 kg B/ha (Thapa, 2006). In contrast. Òztùrk et al (2007) reported that B decreased oil content in canola and suggesting that the effects of B on rapeseed oil content is under debate. The B deficiency may cause sterility i.e. less pods and less seeds per siliqua attributing lower yield (Islam and Anwar, 1994). This emphasizes the need for a judicial use of B fertilizer. However, little is known whether B regulates plant growth, seed yield, oil content and germination percent of rapeseed.

Proper dose of fertilization is an essential tactic to maximize rapeseed production in Bangladesh soil. The N deficiency is widespread in Bangladesh. Consequently, in addition to N, P and K other nutrients such as S, Zn, and B deficiencies are also observed in some soils (Islam, 1988; Ali et al., 1988 and Jahirruddin et al., 1992). The combined application of N and B significantly increased protein content in seed over N along. Concerning the effect of B on nutrient uptake, six element followed the order K>N>S>P>B>Zn and these were significantly influenced with B (Hossain et al. 2011). However, to my knowledge little is known whether different doses of N along with different doses of B regulate the growth, yield, oil content and germination percent of rapeseed using the variety-BARI Sarisha 14. Considering the above proposition this study has been undertaken to investigate the growth, yield, oil content and germination percent of rapeseed variety BARI sarisha 14 with different levels N and B. In view of these background a field experiment containing the treatments of N and B was conducted with the following objectives:

- To investigate effects of N and B on the growth, seed yield and oil content of rapeseed variety BARI sarisha 14.
- To evaluate the interaction effects of N and B on growth, seed yield and oil content of rapeseed variety BARI sarisha 14.
- To find out the best combination of N and B for better seed yield, oil content and germination percent of rapeseed variety BARI sarisha 14.

# Chapter 2
# Review of literature

# Chapter 2

## REVIEW OF LITERATURE

Among the oilseed crops, Rapeseed occupies the topmost position in Bangladesh. The proper nutrient management essentially influences its growth and yield performance. Experimental evidences showed that there is a profound influence of nitrogen (N) and boron (B) fertilizers on this crop. A brief of the relevant works performed in the past are presented in this Chapter

### 2.1 Effect of nitrogen (N) on Rapeseed:

Nitrogen is an essential macronutrient. High yielding mutants / varieties of mustard are very responsive to nitrogen (Ali and Rahman, 1986 and Gupta et al.,1985). Nitrogen is essentials for cell division and expansion, chloroplast development, chlorophyll concentration and enzyme activity (Gardner et al.,1985).

A field experiment was carried out by Seyedeh Neda Mozaffari, Babak Delkhosh and Amirhossein Shirani Rad (2012) at Qazvin-Iran during 2009-2010 to assess the effect of different levels of nitrogen (N0, N75, N150 and N225 kg ha-1) and potassium (K0, K45, K90 and K135 kg ha-1) on yield and some of the agronomical characteristics in Mustard (Brassica juncea). The results showed that increased amount of nitrogen and Potassium up to 225 kg N ha-1 and 135 kg K ha-1 respectively had a positive and significant ($p<0.01$) effect on thousand seed weight (TSW), seed yield (SY) and seed oil yield (SOY).

A field experiment was conducted by Varsha Gupta, Vikas Pratap, Singh Bhadauria and R.L. Aarwal (2011) during the rabi season of 2003-2004 and 2004-2005. They reported from their field experiment that higher dose of nitrogen 120 kg N/ha produced maximum oil yield.

A field experiment was conducted by Patel *et al.* (2004) during the rabi season of 1999-2000 in Gujarat, India to investigate the effects of irrigation schedule, spacing (30 and 40 cm) and N rates (50, 75 and 100 kg/ha) on the growth, yield and quality of Indian mustard cv. GM-2. In combination treatments, 3 irrigation + N at 100 kg/ha + spacing of

45 cm resulted in a significant increase in yield. Growth, yield attributes and seed yield increased with increasing N levels, while oil content decreased with increasing rates. The highest benefit cost ratio was also obtained with N at 100 kg/ha.

A field experiment was conducted by Sinsinwar et al. (2004) during the 1999/2000 and 2000/01 rabi seasons in Bharatpur, Rajsthan, India to determine the best cropping sequence and N fertilizer application rate (0, 30, 60 and 90 kg/ha) of Indian mustard cv. RH-30 under brackish water situation. The cropping sequences comprised: pearl millet + black gram followed by Indian mustard : pearl millet + pigeon pea followed by Indian mustard; black gram followed by Indian mustard; cluster bean followed by Indian mustard; and fallow followed by Indian mustard. The cropping sequences did not affect the growth, yield and yield components (i.e. plant height, number of primary and secondary branches per plant, number of siliquae per plant), 1000-seed weight and seed yield in both years. The seed yield of Indian mustard significantly increased with each increment of N fertilizer up to 60 kg/ha, beyond which the increase was marginal. On an average , the increase in seed yield compared to the control was 33.3 and 83.8% with 30 and 60 kg N/ha, respectively. The Indian mustard seed equivalent yield was significantly highest in pearl millet + black gram followed by Indian mustard (3190 kg/ha) cropping sequence during 1999/2000. In 2000/01, the Indian mustard equivalent yield of pearl millet + black gram followed by Indian mustard was highest (2435 kg/ha).

Singh *et al.* (2004) reported that nitrogen application did not affect the oil content in mustard but oil yield and chlorophyll content were increased up to 90 kg N/ha over the control. Nitrogen application increased the seed yield of mustard. Nitrogen and sulfur content both in seed and straw and total N and S uptake enhanced due to application of 90 kg N/ha over its preceding rates. The increased nitrogen and sulfur content enhanced the total uptake of nitrogen and sulfur.

Prasad *et al.* (2003) stated that N at 30 kg/ha + P at 20 kg/ha + Zn at 5 kg/ha, and N at 60 kg/ha + P at 30 kg/ha + S at 20 kg/ha produced the highest growth, yield and productivity, and also good cost: benefit ratio.

An experiment was conducted by Tripathi (2003) in Uttar Pradesh, India in 1994- 95 and 1995-96 to investigate the effects of N levels (80, 120, 160 and 200 kg/ha) on the growth, yield and quality of Indian mustard cv. Varuna. Nitrogen was applied at 3 equal splits, at sowing, at first irrigation and at 60 days after sowing. Results showed that all the yield characters except number of branches increased with increasing N levels up to 160 Kg N/ha. The number of branches per plant increased up to 200 Kg N/ha. Net returns were maximum (Rs. 19 901/ha) at 160 Kg N/ha because seed yield was also maximum at this N rate. The benefit: cost ratio increased up to 160 Kg N/ha, with a maximum of Rs. 209 earned per rupee investment.

Field experiments were conducted by Abdin et al. (2003) in Rajasthan, Haryana and Uttar Pradesh, India to study the effects of S and N on the yield and quality of Indian mustard cv. Pusa Jai Kisan (V1) and rape cv. Pusa Gold (V2). The treatments comprised: Ti (S0:N50 + 50); T2 (S40:N50 + 50 for V1 and S40:N50+25 + 25 for V2); and T3 (S20 + 20:N50 + 50 for V1 and S20 + 10 + 10:N50 + 25 + 25 for V2). Split application of S and N (T3) resulted in a significant increase the seed and oil yield of both crops. The average seed yield obtained from the different experimental sites in the three states was 3.89 t/ha for V1 and 3.06 t/ha for V2 under T3. The average oil yield under T3 was 1.71 t/ha for V1 and 1.42 t/ha in V2. The oil and protein contents in the seeds of V1 and V2 also increased with the split application of S and N. It may be concluded from these results that the yield and quality of rapeseed-mustard can be optimized with the split application of 40 kg S/ha and 100 kg N/ha during the appropriate phenological stages of crop growth and development.

Khan *et al.* (2003) observed that cycocel at 400 ppm + 60 kg N/ha and ethrel at 200 ppm + 80 kg N/ha enhanced leaf photosynthetic rate, water use efficiency, leaf area and leaf dry mass 80 days after sowing. The highest stem, pod and plant dry mass were noted 120 days after sowing. At maturity, pod number and seed yield increased.

Singh and Prasad (2003) stated that among the N rates, 120 kg/ha gave the highest seed yield (20.24 quintal/ha), straw yield (12.22 quintal/ha), stick yield (43.52 quintal/ha), and net profit (12 975 rupees/ha). The highest cost benefit ratio (0 85) was obtained with 180 kg N/ha. [1 quintal=100 kg].

Singh *et al.* (2003) stated that N at 120 kg/ha produced 4.51 higher number of branches, 48.03 higher siliqua number, 2.09 g siliqua weight, 2.05 g higher seed t per plant and 2.55 q/ha higher seed yield compared to 60 kg N/ha. The N level higher than 120 kg/ha did not increase the yield and yield attributes significantly. The basis of N application did not significantly affect the performance of the plants.

Sinha *et al.* (2003) fertilized rapeseed cv. B-9 plants with 0, 30, and 60 kg N/ha under irrigated or non-irrigated conditions in a field experiment. They observed that plant height increased with increasing rate of nitrogen and was higher under irrigated than non- irrigated conditions. Singh *et al.* (2002) also reported that plant height increased significantly with successive increase in nitrogen up to 120 kg/ha.

Babu and Sarkar (2002) reported that mustard cultivars responded to N application up to 80 kg $ha^{-1}$ Dry matter yield, N content, N uptake and per cent Ndff by mustard cultivars significantly increased with an increase in the level of fertilizer N. Per cent Ndff significantly increased from 12 at 40 kg N $ha^{-1}$ to 22 at 80 kg N $ha^{-1}$ in mustard seed while in stover the corresponding values ranged from 11 to 20%. Successive levels of N also increased significantly the uptake of soil N by mustard cultivars clearly establishing the 'priming' or 'added nitrogen interaction effect' of applied nitrogen.

Meena *et al.* (2002) revealed that the application of 60 kg N/ha registered significantly higher seed and stover yield of mustard over control and 30 kg N/ha and found statistically at par with 90 kg N/ha.

Budzynski and Jankowski (2001) stated that the effects of pre-sowing application of NPK (161 kg/ha)+S (30 kg/ha) or Mg (5 kg/ha) and top dressing of N (0, 30, 25+5 and 60 kg/ha) on the yield, yield components and morphological features of white mustard [*Sinapsis alba*] and Indian mustard seeds were evaluated in an experiment conducted in Poland. N top dressing (30, 25+5 and 60 kg/ha) increased the height, diameter of stem base and branching of Indian mustard and white mustard stems. Both crops, however, exhibited lodging. The effects of NPKS and NPKMg on the yield potential of white mustard were not dependent on weather conditions N applied at 30 kg/ha at the start of the flowering period gave the best results among the methods of white mustard top dressing. Splitting this rate to 25 kg N/ha as a solid fertilizer and 5 kg N/ha in a solution gave results similar to that of the whole rate of 30 kg N/ha as a solid fertilizer. N at 60 kg/ha appeared to be less productive. N applied as a solid fertilizer at a rate of up to 60 kg/ha increased the seed yield. Splitting the N rate to 25 kg/ha (solid fertilizer) and 4 kg/ha (solution) gave yield-enhancing effects similar to that of the whole 30 kg N/ha rate.

Singh (2002) found that application of N and P increased the length of siliqua, number of siliquae per plant, seeds per siliqua, seed yield and 1000-seed weight of mustard. However, the significant increase in yield and yield components was recorded in 60, 90 and 120 kg N/ha and 30, 45 and 60 kg P/ha treatments. The maximum seed yield was recorded from application of 45 kg P/ha (11.43 and 13.85 q/ha in 1999 and 2000, respectively) and 120 kg N/ha (12.98 and 13.83 q/ha in 1999 and 2000, respectively). The oil content also increased with the application of N and P, but was not significant

Kader *et al.* (2003) observed that the effects of row spacing (30, 45 or 60 cm) and N rate (60, 120 or 180 kg/ha) on the yield of Indian mustard cv. Basanti were studied. N was applied at sowing (50%) and after the initial irrigation (50%). They found among the N rates, 120 kg/ha gave the highest seed yield (20.24 quintal/ha), straw yield (12.22 quintal/ha), stick yield (43.52 quintal/ha), and net profit (12975 rupees/ha). The highest cost benefit ratio (0.85) was obtained with 180 kg N/ha. [ 1 quintal=100 kg].

Field experiments were conducted by Jamal et al. (2003) in Rajasthan, Haryana and Uttar Pradesh, India to study the effects of S and N on the yield and quality of Indian mustard cv. Pusa Jai Kisan (V1) and rape cv. Pusa Gold (V2). The treatments comprised: Ti (S0:N50 + 50); T2 (S40:N50 + 50 for V1 and S40:N50+25 + 25 for V2); and T3 (S20 + 20:N50 + 50 for V1 and S20 + 10 + 10:N50 + 25 + 25 for V2). Split application of S and N (T3) resulted in a significant increase the seed and oil yield of both crops. The average seed yield obtained from the different experimental sites in the three states was 3.89 t/ha for V1 and 3.06 t/ha for V2 under T3. The average oil yield under T3 was 1.71 t/ha for V1 and 1.42 t/ha in V2. The oil and protein contents in the seeds of V1 and V2 also increased with the split application of S and N. It may be concluded from these results that the yield and quality of rapeseed-mustard can be optimized with the split application of 40 kg S/ha and 100 kg N/ha during the appropriate phenological stages of crop growth and development.

Ozer (2003) studied two cultivars (Tower and Lirawell) of rapeseed with four levels of nitrogen (0, 80, 160 and 240 kg N/ha). He observed that adequate N fertilization is important in increasing siliqua number per plant and 1000-seed weight in summer oilseed rape. He suggested that the rate of 160 kg N/ha will be adequate for the crop to meet its N requirements.

Singh and Prasad (2003) reported that 120 kg N/ha gave the highest seed yield (20.24 q/ha). But the highest cost benefit ratio (0.85) was obtained with 180 kg N/ha.

Kumar and Singh (2003) conducted an experiment during rabi season with different levels of nitrogen for Indian Mustard (*Brassica juncea*). They reported that the maximum seed yield (24.51 q/ha) was observed with 150 kg N/ha.

Singh and Meena (2003) conducted a field experiment to determine the effect of N fertilizers (20, 40, 60, 80 and 100 kg N/ha) on the oil and protein yield of Indian mustard cv. Varuna. Results showed that 40 kg N/ha gave the highest oil content (39.61%).

Meena and Sumeriya (2003) canied out a study to evaluate the effect of nitrogen (0, 30, 60 and 90 kg/ha) on oil content of mustard (*Brassica juncea*). Application of 60 kg N/ha gave the maximum oil content (37.04%) compared to no nitrogen application. Abadi c (2001) also indicated that N had a significant effect on oil content of rapeseed and mustard.

Sharawat *et al.* (2002) observed that the yield and oil content generally increased with the increase in N and S rate. N at 120 kg/ha resulted in the highest number of siliquae per plant (397 25), weight of siliquae per plant (33 32 g), number of seeds per siliqua (14.80), seed yield per plant (368.75 g), 1000-grain weight (17.33 g), seed yield per ha (17.33 quintal) and oil content (38.39%).

Saikia *et al.* (2002) stated that dry matter and seed yield affected by different level of N. Sharma and Jain, (2002) reported that the application of 80 kg N/ha resulted in the highest number of branches (24.4) and siliquae (260.9) per plant, number of seeds per siliqua (15.3), 1000-seed weight (5.85 g), and seed yields (1649, 2217, and 1261 kg/ha).

Shukla *et al.* (2002b) conducted an experiment to observe the effect of nitrogen for Indian mustard ( *B. juncea*). They found that maximum number of siliquae per plant, maximum siliqua length, maximum number of seeds per siliqua, maximum 1000-seed weight and maximum seed yield per hectare was obtained with the application of 120kg N/ha. Singh *et al.* (2002) also reported that growth characters and length of siliqua increased significantly with successive increase in nitrogen up to 120 kg/ha.

Abadi *et al.* (2001) indicated that N had significant effect to increase the number siliquae per plant of rapeseed up to 120 kg N/ha.

Sidlauskas (2000) observed that the yield of rapeseed was increased with the increasing rate of nitrogen levels up to 120 kg. Further increase of nitrogen level did not affect the seed yield.

BARI (1999) performed trial in two different regions of Bangladesh, at Joydebpur & Ishwardi to find out the effect of N on the yield of mustard. The experiment was conducted with 3 levels of nitrogen 0, 120, 160 kg/ha and plant height was found 87.78, 113.94, 106.46 cm, respectively at Joydebpur and 90.79, 118.46. 113.69 cm at Ishwardi. The highest plant height was found in both the location at 120 Kg N/ha.

BARI (1999) reported 22.7, 42.0, 45.6 and 48.0 siliquae per plant of mustard with o, 80, 120 and 140 N kg/ha respectively.

BARI (1999) reported yields of mustard 493.3, 833.3, 940.0 and 993.7 kg/ha showed with four levels of nitrogen (0, 80,120, kg/ha) respectively.

Singh *et al.* (1998) reported that seed and oil yields as well oil component values were increased with increasing nitrogen rates (0, 40, and 80 kg N/ha).

Islam and Mondal (1997) in a field trial showed that application of four levels of nitrogen 0, 100, 200, 300 kg/ha yielded 0.69, 1.29, 1.45, 1.21 t/ha seeds, respectively.

Hossain and Gaffer (1997) conducted an experiment with 5 levels of nitrogen viz. 0, 100, 150, 200, 250 kg/ha on rapeseed and maximum yield was found 1,73 t/ha with 250 kg N/ha.

Islam and Mondal (1997) showed that the maximum plant height was obtained 93.6 cm at 300 kg N/ha while applying different levels of nitrogen i.e. 0, 100, 200, 300 kg/ha.

Patil et al. (1997) cultivated *B. juncea* CV. pusa Bold and B. campestris CV. pusa kalayania under field conditions in New Delhi with 0, 40, 80 and 120 kg N ha and observed changes in dry matter accumulation in various plant parts due to the influence of N. The application of N-fertilizer up to 120 kg $ha^{-1}$ had effect on the increasing growth of leaves, stems and pods during the entire period of crop growth.

Shukla and Kumar (1997) grew six varieties of Indian mustard to assess the effect of nitrogen fertilization on yield attributes, seed yield and oil content. They found that N application at the rate of 120 kg/ha significantly influenced harvest index.

Ali *et al.* (1996) found that application of 120 kg N/ha favourably influenced the oil yield of rapeseed.

Tomer *et al.* (1996) reported the highest seed yield of cv Varuna (2 86 t $ha^{-1}$) and Pusa (2.72 t $ha^{-1)}$ with the highest dose of N 160 kg $ha^{-1}$ over control.

Shahidullah *et al.* (1996) observed in a fertilizer trial with 0, 75, 100 and 150 kg ha of N, the seed yield of the *B. Juncea* CV. Sonali sarisha, Daulat, Tori-5 were increased up to a dose of 100 kg N $ha^{-1}$. The highest yield was obtained from CV. Sonali sarisha.

Patil *et al.* (1996) reported that the effect on growth, yield components and seed yields of *B. juncea* that the branching pattern and number of pods produced on different order of branches, in the two species, were favorable modified by the incieasing levels of N apply. Primary and secondary branches contributed to the seed yield to an extent of 80% of the total. Yield without any significant effect of N on 1000 seed weight *B. juncea* exhibited significantly higher yield than *B. cainpestris*. Nitrogen supply up to 120 kg $ha^{-1}$ linearly increased seed yield in both the species.

Kakati and Kalita (1996) found that most of the yield components (branches plant$^{-1}$, Siliqua plant$^{-1}$, seed and stover N content) increase with the increasing rate of N-fertilizer, while oil content of seed decreased, 1000 seed weight and number of seeds siliqua remained unchanged. The cv. Varuna was found to be highest yielding cultivar.

Mondal *et al.* (1996) reported that the highest seed yield of rapeseed ( 1.40 t/ha) was obtained from fertiflzer levels of 150:90:100:30:4:1 kg/ha of N, $P_2O_5$, $K_2O$, S, Zn and B along with 6 tones cowdung.

Tuteja *et al.* (1996) investigated the effect of nitrogen at 60, 90 and 120 kg/ha on the yield of *Brassica juncea* cv. Varuna. Seed yield was highest (1.12 t/ha) with 120 kg N/ha.

Ali and Ullah (1995) reported maximum plant height with 120 kg N/ha when different doses of nitrogen 0,40.90, 120 kg/ha were given to the plant.

Gawai *et al.* (1994) performed an experiment to assess the impact of 0-100 kg N/ha on the performance of mustard (*B. Juncea*) cv. TM-17 and concluded that oil yield increased with N rate, reaching a plateau at 75 kg/ha.

Khanpara *et al.* (1992) in a field experiment on clay loam soil with mustard (*B. Juncea*) observed that the level of 60 kg N ha$^{-1}$ was significantly superior to other levels for seed yield, plant height and primary and secondary branches plant$^{-1}$. Islam et al., (1992) from their field trail at Mymensingh found increased seed yield of mustard cv. Sambal from 0.73 to + 1.91 t ha$^{-1}$ with 0-200 kg N ha$^{-1}$ applied at the different stages of the growth.

Tomer and Mishra (1991) observed that N application increased seed yield of mustard (*B. Juncea.*) from 0-32 to 1.12 ton ha$^{-1}$. Singh and Chauhan (1991) found a field trials that application of 60 kg N ha$^{-1}$ as urea to mustard resulted in higher seed yield (1.53 t ha$^{-1}$) than that of 30 kg N applied as urea.

Rana *et al.* (1991) reported that nitrogen application at the rate of 0, 50, 100, 150 kg $ha^{-1}$ increased yield gradually and it reached maximum by N application up to 100 kg $ha^{-1}$. Dubey and Khan (1991) observed that nitrogen at the rate of 90 kg N $ha^{-1}$ significantly increased seed yield of mustard under irrigated condition.

Sharma and Kumar (1990) observed that application of 120 kg N $ha^{-1}$ increased the seed yield of mustard but it is not significantly superior to that of 80 kg N $ha^{-1}$. With the application of 1 kg N, on and average, produced 11.48 kg seeds against the treatment of 120 kg N $ha^{-1}$. On the other hand, with the addition of 80 kg N $ha^{-1}$, 1 Kg N produced 10.96 kg seeds.

Ali *et al.* (1990) obtained higher seed yield of rapeseed when 90 kg N $ha^{-1}$ was applied under rainfed condition.

Jensen (1990) observed 1974.0, 2936.6, 3315.1 and 5023.8 siliquae per plant in 0,50, 100 and 200 kg N/ha, respectively.

Sounda *et al.* (1989) reported from a two years trial under rainfed condition with mustard (*B. juncea*) that increasing rates (0-90 kg $ha^{-1}$) of nitrogen increased seed yield from 245 to 628 kg $ha^{-1}$ in one year and also from 277 to 778 kg $ha^{-1}$ in another year.

Murtaza and Paul (1989) in a pot culture studied three cultivars of rape seed Viz. Pola, Tori-7 and Sampad grown with four levels of N-Fertilizer (0, 5, 10, 20 g of urea) bserved significant effect of nitrogen on the number of primary branches $plant^{-1}$, siliqua $plant^{-1}$ seed $siliqua^{-1}$ and weight and seed yield $plant^{-1}$.The cultivars showed significant differences in all the characters except the number of primary branches and siliqua $plant^{-1}$.

Perniona *et al.* (1989) sifidied the effect of nitrogen (50, 100 and 150 kg/ha) on winter rape and found that average seed yield increased with the increased rate of nitrogen at 150 kg/ha.

Singh and Saran (1989) conducted an experiment with *Brassica campestris* var. Toria and with different doses of nitrogen. They found that nitrogen at the rate of 60 kg/ha increased plant height, the number of siliquae per plant, seed yield and 1000-seed weight.

Shrivastava *et al.* (1988) observed in an experiment conducted with musrard (*Brassica juncea* cv. varuna) that the application of nitrogen at the rate of 90 kg/ha at the preflowering stage gave highest harvest index.

Singh and Singh (1987) stated that increasing rate of nitrogen from 75 kg /ha applied to mustard (*Brassica juncea*) increased the seed yield from 1.20-1.33 to 2.11-2 14 t/ha.

Shamsuddin *et al.* (1987) working with mustard with five levels of nitrogen (0,30, 60, 90 and 120 kg N /ha) and four levels of irrigation observed that plant height increased progressively with increasing levels of nitrogen application but was not significantly differed with the application of different levels of nitrogen. Nitrogen at the rate of 120 kg /ha gave taller plant, highest no of primary branches of plant (5 30) and the highest seed yield (830 kg /ha) over control. Thousand seed weight also increased significantly due to application of nitrogen.

Singh and Saron (1987) set an experiment with *Brassica campestris* var. toria (*Brassica napus* var. toria) applied different doses of nitrogen. They found that nitrogen at the rate of 60 kg/ha increased plant height, number of pods/plant and 1000-seed weight. This dose gave seed yields of 1.20 t/ha compared to 0.89 t/ha without nitrogen. A further increase in yield with 90 kg N/ha was not significant.

Hasan and Rahman (1987) showed that application of nitrogen at the rate of 120 Kg $ha^{-1}$ increased the plant height, number of pod in the primary branches and in the main racemes and seed yield of mustard. *B. campestris* cv. Kalayania with nitrogen up to 120 kg $ha^{-1}$ gave highest plant height, seed, stover and biological yield, while 60 kg N $ha^{-1}$ resulted the highest number of primary branches, siliqua, seed weight $plant^{-1}$ and 1000-seed weight.

Narang and Singh (1985) fertilized Indian mustard with four levels of nitrogen ( viz. 0, 50, 100 and 150 kg /ha). They have observed that nitrogen at the rate of 150 kg /ha gave highest seed yield (1.8 t /ha) over control.

Mondal and Gaffer (1983) working with mustard give five levels of nitrogen viz. 0, 35, 105 and 140 kg/ha observed that different levels of nitrogen had significant effects on the plant height, number of primary branches/plant, number of filled siliqua/plant, number of seeds/siliqua, weight of seed/plant, weight of total dry plant/plot and yield of seeds over control. They further, observed that plant height, number of primary branches/plant and number of filled siliqua/plant were increased with the increasing doses of nitrogen. Nitrogen at the rate of 140 kg/ha produced highest number of fertile seeds/siliqua and seed yield (1.3 t/ha).

Patel *et al,* (1980) performed a field experiment with four levels of nitrogen (viz. 0, 25, 50 and 75 kg /ha) They reported that different levels of nitrogen gave different seed yields of mustard significantly. The highest seed yield was 0 73 t /ha achieved at the rate of 50 kg N /ha due to the formation of higher no. of secondary branches /plant, higher no. of siliquae /plant and higher harvest index.

Bhan and Singh (1976) reported that *Brassica juncea* was found taller plant height with 120 kg N/ha.

**2.2 Effect of Boron (B) on Rapeseed:**

Hussain et al. (2011) reported that the grain B concentration increased from 19.96 µg/g in B control to 45.99 µg/g and 51.29 µg/g due to application of 1 kg and 2 kg B/ha, respectively. Concerning the effect of B on the nutrient uptake, six elements followed the order K> N> S> P> B> Zn and these were significantly influenced by B application.

Hussain *et al.* (2008) reported from two years experiment that 1-1.5 kg boron/ha should be applied along with recommended fertilizers produced higher seed yield. BARI sharisha-11 and BARI sharisha-8 performed better and highly response to boron than BARI sharisha-9.

Mollah *et al.* (2005) conducted an experiment to find out the suitable doses of Boron for yield of mustard varieties. Three doses of boron fertilizer viz, 0.1.0 and 2.0 kg/ha were used on five varieties of mustard. He reported that application of 1.0 to 2.0 kg B/ha significantly influenced on the seed yield of mustard varieties under the test over control.

Boron is a micronutrient requiring for plant growth relatively to a smaller amount. The total B content of soils lies between 20 and 200 ppm with the available (hot water soluble) B fraction ranging from 0.4 to 0.5 ppm (Gupta, 1979). Plants absorb B principally in the form of $H_3BO_3$ and to a smaller extent as $B_4O_7^{2-}$, $H_2BO_3^-$ and $HBO_3^{2-}$ .The element plays a vital role in the physiological processes of plants such as cell nutrition, cell elongation and cell division, carbohydrate, protein and nucleic acid metabolism, cytokinin synthesis, auxin and phenol metabolism. The function of boron is primarily extra cellular and related to lignification and xylem differentiation (Lewis, 1980), membrane stabilization (Pilbeam and Kirkby, 1983), and altered enzyme reactions (Dugger, 1983).

Boron has both direct and indirect effects on fertilization. Indirect effects are related to the increase in amount and change in sugar composition of the nectare, whereby the flowers of species that rely on pollinating insects become more attractive to insects (Smith and Johnson, 1969; Erikson, 1979). Direct effects of boron are reflected by the close relationship between boron supply and pollen producing capacity of the anthers as well as the viability of the pollen grains (Agarwala et al., 1981). Moreover, boron stimulates germination, particularly pollen tube growth. Boron is also essential for sugar translocation, thus affecting carbon and nitrogen metabolism of plants (Jakson and Chapman, 1975).

Gupta (1979) stated that some plant species have a low B requirement and may also be sensitive to elevated B level even only slightly above those needed for normal growth. Therefore, toxic effects of B are likely to arise due to excessive use of B fertilizers.

Juel (1980) reported from 17 trials that the application of boron at the rate of 2 Kg /ha resulted in increased seed yield of mustard and oil content of seed.

Gerath et al. (1975) reported an increase in yield of winter rape through application of boron fertilizer and recommended an application of 1 to 2 kg B/ha for increased yield.

Islam and Sarker (1993) reported that the application of boron increased significantly the number of siliquae / plant, no. of seeds /siliqua and seed yield of mustard (cv. ss-75) at Rangpur Agricultural Research Station. From another study it was reported that application of boron on mustard (cv. ss-75) significantly increased the seed yield in farmer's field at Jamalpur.

Thomas (1985) reported that the highest yields were achieved on medium to heavy soil with 40 kg N and P, 80 kg K, 1 kg B and 30 kg S /ha applied before sowing, plus 180 kg to 220 kg N /ha applied as top dressing in two installments in late February to early March.

Chakravarty *et al.* (1979) stated that boron concentration in all crops increased significantly with increasing level of applied boron.

Yadav and Manchandra, (1982); Dutta et al., (1984) and Yang et al., (1989) also reported that increased level of boron application in mustard (*B. campestris*) increased tissue B content.

Sharma and Ramchandra (1990) reported that boron deficiency in mustard (*B. campestris*) decreased dry matter yield. Boron deficient plant had low water potential, stomatal pore opening and transpiration, decreased chlorophyll concentration, hill reaction activity, inter-cellular concentration and photosynthesis but there was an increase in accumulation of soluble nitrogen, protein, sugar and starch.

Marchner (1990) reported that the deficiency symptoms of some boron sensitive crops like legumes, *Brassica*, beets, celery, grapes and fruit trees are chiorosis and browning of young leaves, killed growing points, distorted blossom development, lesions in pith and roots, and plants, burning of the tips of the leaves and restricted root growth are the boron toxicity symptoms in most crops.

Application of boron significantly increased the yield of mustard and 1.5 kg B /ha appeared to be the optimum B level for mustard (Sinha et al., 1991; Dixit and Shukla, 1984). Banuels et al. (1990) reported that the application of P, S, Zn, and B raised seed yield of mustard significantly. Combined application of N, K and B increased seed yield in rapeseed (Yang et al., 1989).

Chatterjee *et al.* (1985) reported that the application of sulphur at the rate of 20 Kg /ha through gypsum in conjugation with borax (10 kg /ha) caused 42% increase in yield of mustard (*B. juncea*). The straw yield of mustard crop increased significantly by boron application (Sinha et al., 1991). Application of B along with N and K promoted $co_2$ assimilation, nitrate reductase activity in leaves and dry matter accumulation. Seed glucosinolate and erucic acid content varies among cultivars and generally decreases with increasing K and B, while seed oil content increases (Yang et al., 1989).

Sen and Farid (2005) reported that application of boron @ 1.5 kg/ha produced 37% higher yield over control.

Application of B (1 kg /ha) increased leaf area ratio (LAR), leaf area index (LIA), crop growth rate (CGR), no. of brunches /plant, no. of siliquae /plant, weight of seed/ siliqua and a decrease in chlorophyll content and net assimilation rate (NAR), but the relative growth rate (RGR), total dry matter and seed yield and some of other growth attributes were unaffected (Dutta and Uddin, 1983; Dutta et al., 1984).

Increasing rate of B application from 0 to 6 ppm had no effect on thy matter and seed yield of mustard (Yadav and Manchandra, 1982).

Sarkar *et al.* (2004) conducted a field experiment to identify cultivars with tolerance to micronutrient stresses. Boron treatments were: 0, 2 and 5 kg borax (0, 0.221 and 0.553 kg B, respectively). Based on the grain yield and its component characters, 14 cultivars of rapeseed and mustard can be classified as highly boron- responsive, moderately-responsive and non-responsive with respect to response of the cultivars to boron, applied to the highly boron deficient soil. The genotypes included 10 cuitivars of *Brassica juncea*, 2 of *Brassica cainpestris* var. sarson and 2 of toria (*B. campestris* var. toria). The cultivars RLM 619, NDR 8602, PBM 16, RK 9082 and C-3 were found to be highly boron responsive. The cultivar T-9 was boron non-responsive, while rest of the cultivars were found to be moderately boron-responsive.

A field experiment was conducted by Malewar (2001) on a Typic Haplustert in Maharashtra, India to investigate the effects of four levels of zinc sulfate (0, 10, 20 and 30 kg/ha) and three levels of borax (0, 5 and 10 kg/ha) on yield, nutrient uptake and seed quality of mustard (*Brassica juncea* cv. Pusa Bold). Stover and seed yield significantly increased with each levels of either zinc or boron, which was attributed to the positive interaction of the two. Highest total mustard uptake of Zn and B was at 30 kg ZnSO4 and 10 kg borax/ha, respectively. Zn and B interaction was also reflected in terms of improved seed quality of mustard. Oil and protein content was significantly increased with 30 kg ZnSO4 x 10 kg borax/ha treatment.

Sinha *et al.* (2000) stated that mustard (*Brassica campestris*) cv. T9 was grown in refined sand at three levels of boron (B): deficient (0.0033 ppm), normal (0.33 ppm), and excess (3 3 ppm), each at three levels of zinc (Zn): low (0 00065 ppm), adequate (0.065 ppm), and high (6.5 ppm). The B deficiency effects were accentuated by low zinc, viz. the decreased biomass, B and Zn concentrations in leaves and seeds and the activity of carbonic anhydrase [ carbonate dehydratase] and accumulation of reducing sugars and stimulated activities of peroxidase, ribonuclease, and acid phosphatase in B deficient leaves were aggravated further. Synergism was also observed between the two nutrients when both B and Zn were in excess together, as excess B accelerated the effects of high Zn by lowering further the reduced biomass, economic yield, and carbonic anhydrase activity and raised further the increased concentration of B and Zn in leaves and seeds, reducing sugars and activity of peroxidase obtained in excess Zn. High Zn levels lowered the high content of non-reducing sugars given by B deficiency.

Gupta *et al.* (1996) reported that mustard [*Brassica juncea* ] cv. GSL-1, Pusa Bold and RS-1359 grown in the rabi [winter] seasons of 1992/93 and 1993/94 were given recommended NPK fertilizers plus 10 or 20 kg Zn/ha, foliar application of 0.5% Zn, 25 or 50 kg S/ha, or 10 or 20 kg B/ha. Seed yield was highest in cv. GSL-1, and was increased more by S and B than by Zn.

In the field trials on a sandy loam in West Bengal in rabi [winter] 1989/90, application of 20 kg S and 1 kg B/ha to rape-seed mustard [*Brassica juncea*] significantly increased plant height, leaf area index at flowering and crop growth rate, oil content and seed yield (Pradhan and Sarkar, 1993).

A pot experiment was conducted by Rashid and Rafique, (1992). They reported that *B. juncea* cv. Westar was grown in soil and given 0, 0.5, 1, 2, 4 and 8 mg B as $H_3BO_3$ /kg soil. DM yield after 4 and 8 weeks growth increased with up to 1 mg B; application rates > 2 mg B were toxic. The critical B concentration in whole shoots was 57 mg B/kg for 4-week-old plants and 28 mg for 8-week-old plants.

In field trials in 1987-88 with 6 cultivars each of sesame and mustard [*Brassica juncea*] grown with applied NPK + Zn on a B-deficient soil, av. sesame seed yields increased from 502 to 569 kg/ha and mustard seed yields increased from 1.14 to 1.35 t/ha when 1.5 kg B/ha was applied; yields were decreased to 518 kg and 1.30 t, resp., with 2.5 kg B/ha. Sesame cv. OMT-11-6-3 and RT-54 and mustard cv. Pusa Bold were more tolerant of B deficiency than other cultivars, as they removed more B from the soil given no B. They also showed a lower yield response to applied B than more susceptible cultivars. There was a positive correlation between seed B content and uptake. Yield was positively correlated with seed B uptake (Sakal et al., 1991).

Saini *et al.* (1985) observed that seed yield of *B. juncea* were increased by increasing N rates from 0 to 120 kg and 1 kg B/ha. The response to S, Zn and B increased with increase in N rates. Oil content decreased slightly with increasing N rates and increased slightly with S, Zn and B.

From the above information it may be inferred that the optimum level of boron has a positive effect on seed yield but the growth and yield is depressed due to deficient or toxic level of boron.

From the present findings it can be inferred that application of N @ 150 kg/ha and B @ 2 kg/ha is the most suitable combination to achieve the highest seed yield (1.96 t/ha) of mustard which was 165.0% higher over control treatment (0.74 t/ha).

# Chapter 3

# Materials and Methods

# Chapter 3

# MATERIALS AND METHODS

The experiment was undertaken during rabi season (November to February) of 2011-12 to examine the response of nitrogen and boron on growth, yield attributes, yield and seed quality of rapeseed cv. BARI Sarisha- 14.

## 3.1 Experiniental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at $90^{0}22^{'}$ E longitude and 23°41′ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28.

## 3.2 Climatic condition

The experimental area is under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, (October-March) and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season (April-September).

## 3.3 Soil condition

The soil of experimental area situated to the Modhupur Tract (UNDP, 1988) under the AEZ no. 28 and Tejgoan soil series (FAO, 1988). The soil was sandy loam in texture having pH 5.47 - 5.63. The physical and chemical characteristics of the soil have been presented in Appendix I.

## 3.4 Materials

### 3.4.1 Seed

A newly developed, moderately salinity tolerant and high yielding variety of rapeseed, BARI Sarisha- 14 developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur was used in the experiment as a planting material. The seed was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Before sowing germination test was done in the laboratory and percentage of germination was over 95%.

### 3.4.2 Fertilizers

The recommended doses of TSP, MP, Gypsum and $ZnSO_4$ were added to the soil of experimental field along with different levels of Nitrogen (N) and Boron (B). However any N or B fertilizer were not applied to control plot.

## 3.5 Methods

### 3.5.1 Treatments

**Factor A: 4 levels of N (kg/ha)**

$N_0$ = 0 kg N/ha
$N_1$ = 60 kg N/ha
$N_2$ = 120 kg N/ha
$N_3$= 180 kg N/ha

**Factor B: 3 level of B (kg/ha)**

$B_0$ = 0 kg B/ha
$B_1$= 1 kg B/ha
$B_2$ =2 kg B/ha

### 3.5.2 Treatment combination

There are 12 treatment combinations of different N and B doses used in the experiment under as following:

1.$N_0B_0$
2.$N_0B_1$
3.$N_0B_2$
4.$N_1B_0$
5.$N_1B_1$
6.$N_1B_2$
7.$N_2B_0$
8.$N_2B_1$
9.$N_2B_2$
10.$N_3B_0$
11.$N_3B_1$
12.$N_3B_2$

### 3.5.3 Design and layout

The experiment consisted of 12 treatment combinations and was laid out Randomized Complete Block Design (RCBD) with 3 replications. The total plot number was 12 x 3 = 36. The unit plot size was 3 m x 1.5 m = 4.5 $m^2$. The distance between blocks was 1 m and distance between plots was 0.5 m and plant spacing was 30 cm X 5 cm. The layout of the experiment is presented in Appendix II.

### 3.5.4 Land preparation

The land was ploughed with a rotary plough and power tiller for four times. Ploughed soil was then brought into desirable fine tilth and leveled by laddering. The weeds were clean properly. The final ploughing and land preparation were done on 16 November, 2011. According to the lay out of the experiment the entire experimental area was devided into blocks and subdivided into plot for the sowing of mustard seed. In addition, irrigation and drainage channels were prepared around the plot.

### 3.5.5 Fertilization

In this experiment fertilizers were used according to BARI and under as follows:

| **Fertilizers** | **Quantity ($ha^{-1}$)** |
|---|---|
| Urea | As per treatment |
| TSP | 160 kg |
| MP | 110 kg |
| Gypsum | 160 kg |
| ZnSO4 | 7.5 kg |
| Boric Acid | As per treatment |

The amounts of fertilizer as per treatment in the forms of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid required per plot were calculated. Half of urea and total amount of all other fertilizers of each plot were applied and incorporated into soil during final land preparation. Rest of the urea was top dressed after 30 days of sowing (DAS)

### 3.5.6 Sowing of seed

Sowing was done on 18 November, 2011 in rows 30 cm apart. Seeds were sown continuously in rows at a rate of 8 kg/ha. After sowing, the seeds were covered with the soil and slightly pressed by hand.

### 3.5.7 Thinning and weeding

The optimum plant population, 60 plants/ $m^2$ was maintained by thinning excess plant at 15 DAS. The plant to plant distance was maintained as 5 cm. One weeding with khurpi was given on 25 DAS.

### 3.5.8 Irrigation

Two irrigations were given as plants required. First irrigation was given immediate after topdressing and second irrigation were applied 60 DAS with watering can. After irrigation when the plots were in zoe condition, spading was done uniformly and carefully to conserve the soil moisture.

### 3.5.9 Crop protection

As a preventive measure of aphid infestation, Malathion 57 EC @ 2 ml per litre of water was applied twice first at 25 DAS and second at 50 DAS.

### 3.5.10 General observation of the experimental field

The field was investigated frequently in order to reduce losses with weeds competition and insects infestation and diseases infection.

### 3.5.11 Harvesting and threshing

Previous randomly selected ten plants, those were considered for the growth analysis were collected from each plot to analyse the yield and yield contributing characters. Rest of the crops were harvested when 80% of the siliquae in terminal raceme turned golden yellow in colour. After collecting sample plants, harvesting was started on February 15 and completed on February 20, 2012. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

### 3.5.12 Drying and weighing

The seeds and stovers thus collected were dried in the sun for couple of days. Dried seeds and stovers of each plot was weighed and subsequently converted into yield kg/ha.

### 3.6 Data collection

Ten (10) plants from each plot were selected as random and were tagged for the data collection. Some data were collected from sowing to harvesting with 10 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

1. Plant height (cm)
2. Leaves plant$^{-1}$
3. Primary branches plant$^{-1}$
4. Secondary branches plant-1
5. Length of main inflorescence (cm)
6. Siliquae on the main inflorescence
7. Seed weight of 100 siliquae (g)
8. Seed weight plant-1 (g)
9. 1000 seed weight (g)
10. Yield (t/ha)
11. Harvest index (%)
12. Seed oil content (%)
13. Germination percentage (%)



#### 3.6.1 Plant height (cm)

Plant height was measured five times at 10 days interval such as 20, 30, 40,50 and 60 DAS. The height of the plant was measured by scale considering the distance from the soil surface to the tip of the randomly ten selected plants and mean value was calculated for each treatment.

#### 3.6.2 Leaves plant-1

Leaves plant$^{-1}$ was counted five times at 10 days interval such as 20, 30, 40, 50 and 60 DAS of rapeseed plants. Mean value of data were calculated and recorded.

### 3.6.3 Primary branches plant$^{-1}$

Primary branches plant$^{-1}$ was counted five times at 10 days interval such as 20, 30, 40,50 and 60 DAS of rapeseed plants. Mean value of data were calculated and recorded.

### 3.6.4 Secondary branches plant$^{-1}$

Almost secondary branches of all plants including selected plants were found. This is identical with the external features published by BARI for BARI sarisha 14.

### 3.6.5 Length of main inflorescence

The length of main inflorescence of ten plants was measured from the base of the inflorescence to the tip of the main inflorescence with measuring scale. Mean length of main inflorescence was calculated and expressed in cm.

### 3.6.6 Siliquae on the main inflorescence

The siliquae of main inflorescence from ten plants were counted and calculated as per plant basis.

### 3.6.7 Seed weight from 100 siliquae (g)

Hundred siliquae were taken randomly from ten plants of each plot and the seeds were weighed with an electric balance.

### 3.6.8 Seed weight plant$^{-1}$(g)

The separated seeds of ten plants were collected, cleaned, dried and weighed properly. The average seed weight plant$^{-1}$ was then recorded in g.

### 3.6.9 1000 seed weight (g)

A composite sample was taken from the yield of ten plants. The 1000-seeds of each plot were counted and weighed with a digital electric balance. The 1000-seed weight was recorded in g.

### 3.6.10 Yield (t ha$^{-1}$)

After threshing, cleaning and drying, total seed from harvested area were recorded and was converted to t/ ha.

### 3.6.11 Harvest index (%)

Harvest index was calculated by dividing the economic seed yield from the net plot by the total biological yield of seed and stover from the same area (Donald, 1963) and multiplying by 100.

### 3.6.12 Seed oil content (%)

The oil content of seed was determined from Oil Seed Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur- 1701. Oil content of seeds was determined by the following methods of Cocks and Van Rede (1966) and Mehlenbacher (1960). The principle of this methods lies in mixing the sample with a solvent, petroleum ether (BP.40 to 60°C), which was then removed by distillation and the residue was dried and weighed. The extraction procedure was carried out in soxhlet apparatus. The oil content of seed was calculated by following formula

$$\text{Percentage of oil content} = (W_1 \times 100) / W$$

Where,

W = Weight of the sample, and

$W_1$ = Weight of the ether extract

### 3.6.13 Germination percentage

The germination percentage of seed was analyzed from Seed Certification Agency (SCA), Joydebpur, Gazipur. The germination percentage of seed was determined in

$$\frac{Total\ no.of\ seed\ germination}{Total\ no.of\ seed} \times 100$$

## 3.7 Data analysis

The data obtained from the experiment were subjected to statistical analysis following analysis of variance technique (Russell, 1986). The mean differences were tested through least significant difference (LSD) method.

# Chapter 4
# Results and Discussion

## Chapter 4

## RESULTS AND DISCUSSION

The results obtained with different levels of nitrogen (N) and boron (B) and their combination are presented and discussed in this chapter. Data about growth, yield contributing characters and oil content of rapeseed have been presented in both Tables and Figures and analyses of variance and corresponding degrees of freedom have been shown in Appendix.

### 4.1 Plant height

Different levels of N influenced the height of rapeseed plant significantly. The results of this study showed that N significantly increased plant height as dose dependent manner at different days after sowing (DAS) (Fig. 1 and Appendix III). The plant height increased with increasing the age of the plants. The tallest plant (10.37, 20.77, 54.36, 85.18, and 87.46 cm at 20, 30, 40, 50 and 60 DAS respectively) was recorded with $N_2$ (120 kg N $ha^{-1}$). In contrast, the shortest plants were recorded from control ($N_0$) at 20, 30, 40, 50, 60 DAS and height was 8.26, 16.31, 46.07, 69.00, and 74.20 cm respectively. These findings are in agreement with those of Singh *et al.* (2003), Tripathi and Tripathi (2003), Singh *et al.* (2002). Similar findings were reported by Tomar *et al.* (1996), FAO (1999), Ali and Ullah (1995), Shamsuddin *et al.* (1987), Ali and Rahman (1986) and Hassan and Rahman (1987). All together, these results suggest that higher doses of N increase rapeseed plant height at different DAS.

There is no significant variation among the different levels of B in respect of plant height (Fig. 2 and Appendix III). However, plant height increased with increasing levels of boron up to higher level. The tallest plant (10.10, 19.86, 51.73, 81.43 and 83.61 cm at 20, 30, 40, 50 and 60 DAS, respectively) was produced with $B_2$, 2 kg B/ha and shortest plant (8.79, 17.61, 46.92, 76.03 and 80.45 cm at 20, 30, 40, 50 and 60 DAS, respectively) was found in no B condition. These results suggest that B has no contribution to elongation of the axis of the plant during growth period. These are in agreement with the findings of Moniruzzaman et al (2007) who reported that B failed to increase plant height of broccoli.

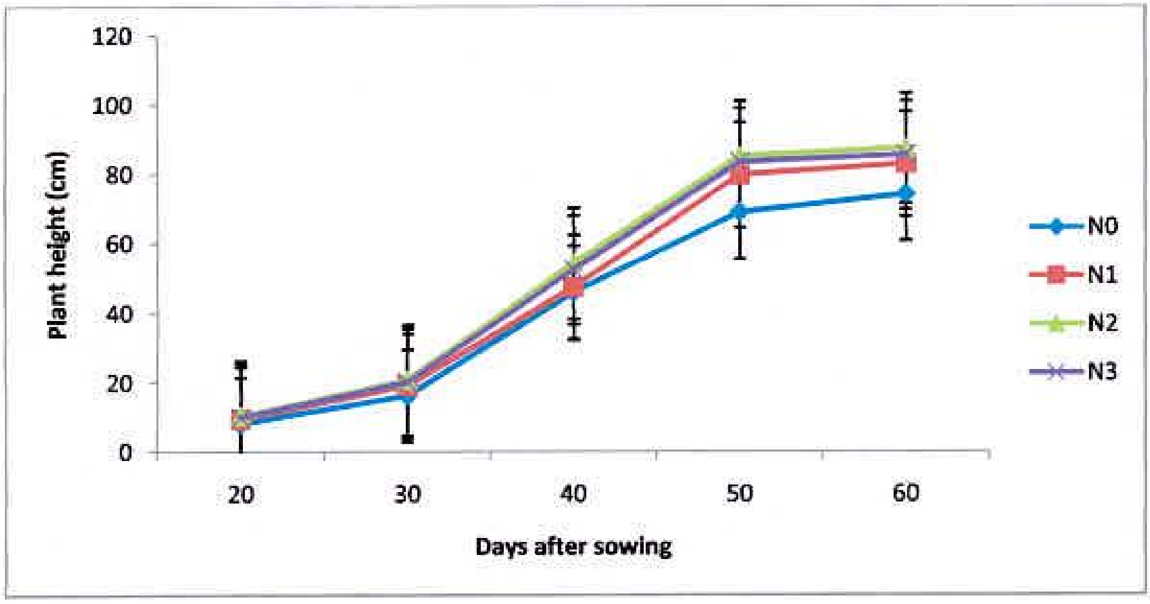


**Fig. 1:** Effect of different doses of N at different DAS on the height of rapeseed plant (DAS = Days after sowing, $N_0$ = without nitrogen, $N_1$ = 60 kg N /ha, $N_2$ = 120 kg N/ha, $N_3$ = 180 kg N/ha, Error bars represent standard deviation)

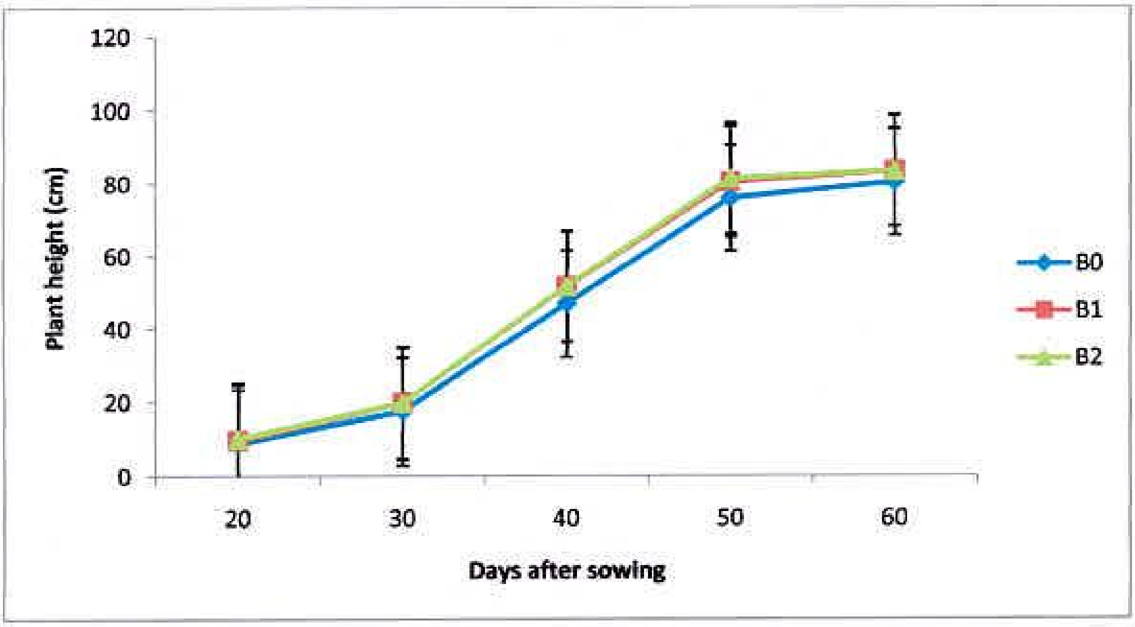


**Fig. 2:** Effect of different doses of B at different DAS on the height of rapeseed plant (DAS = Days after sowing, $B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha, Error bars represent standard deviation)

The combined use of N and B had significant effect on plant height (Table 1, Plate 1&2 and Appendix III). The tallest plant (11.55, 21.87, 54.93, 87.60 and 88.90 cm at 20, 30, 40, 50 and 60 DAS, respectively) was found in $N_2B_2$ treatment combination, 120 kg N/ha with 2 kg B/ha whereas the shortest plant (7.35, 14.50, 43.40, 61.87, and 72.87 cm at 20, 30, 40, 50 and 60 DAS, respectively) was observed in the control treatment combination. Singh et al. (2002) reported that plant height increased significantly with successive increase in nitrogen up to 120 kg/ha. The N increased plant height but B could not show any effect on plant height of rapeseed separately. All together these results indicate that plant height of rapeseed increase with combined use of nitrogen and boron.

### 4.2 Leaves plant-1

A good number of leaves indicated better growth and development of crop. It is also possibly related to the yield of rapeseed. The greater number of leaf, the greater the photosynthetic area which may result higher seed yield. The N showed significant variation in the number of leaves plant$^{-1}$ at 20, 30, 40, 50 and 60 DAS (Fig. 3 and Appendix IV). The maximum number of leaves plant$^{-1}$ (6.77, 8.07, 18.67, 22.04 and 23.38 at 20, 30, 40, 50 and 60 DAS, respectively) was produced by 120 kg N/ha and without N produced the lowest number of leaves plant$^{-1}$ (5.67, 6.24, 12.78, 17.24 and 17.65 at 20, 30, 40, 50 and 60 DAS, respectively). These indicate number of leaves plant$^{-1}$ increased with increasing N levels; those are consistent with Patil et al., (1997) findings.

Number of leaves plant$^{-1}$ due to the influence of B was not significant at 20, 30, 40, 50 and 60 DAS (Fig. 4 and Appendix IV). With the 2 kg B/ha had the highest number of leaves plant$^{-1}$ (6.46, 7.45, 17.87, 21.62 and 22.70 cm at 20, 30, 40, 50 and 60 DAS, respectively). However, the lowest number of leaves plant$^{-1}$ (6.04, 7.02, 14.55, 18.45 and 19.09 at 20, 30, 40, 50 and 50 DAS, respectively) was obtained from the control. So, B has important role on increasing number of rapeseed leaves.

A significant variation in the number of leaves plant$^{-1}$ was found between the N and B (Table 2, Appendix IV). The maximum number of leaves plant$^{-1}$ (7.12, 8.27, 21.87, 24.60 and 26.93 at 20, 30, 40, 50 and 60 DAS, respectively) was found in combined use of 120 kg N and 2 kg B, $N_2B_2$ treatment, whereas the lowest number of leaves plant$^{-1}$ (4.53, 5.40, 11.73, 16.47 and 17.69 at 20, 30, 40, 50 and 60 DAS, respectively)

**Table 1:** Interaction effect of N and B on the height of rapeseed plant at different days after sowing (DAS)

| Treatment | Plant height (cm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 20 DAS | | 30 DAS | | 40 DAS | | 50 DAS | | 60 DAS | |
| $N_0B_0$ | 7.35 | f | 14.50 | g | 43.40 | bc | 61.87 | f | 72.87 | d |
| $N_0B_1$ | 8.77 | e | 17.37 | ef | 47.80 | abc | 72.27 | e | 74.53 | d |
| $N_0B_2$ | 8.65 | e | 17.07 | f | 47.00 | abc | 72.87 | e | 75.20 | d |
| $N_1B_0$ | 8.89 | de | 18.10 | def | 39.80 | c | 75.53 | d | 80.90 | c |
| $N_1B_1$ | 9.73 | bc | 19.80 | bcd | 51.33 | ab | 82.73 | bc | 85.10 | abc |
| $N_1B_2$ | 9.83 | bc | 19.57 | cd | 51.27 | ab | 81.03 | c | 82.80 | bc |
| $N_2B_0$ | 9.32 | cde | 19.00 | de | 53.53 | ab | 83.40 | b | 85.07 | abc |
| $N_2B_1$ | 10.24 | b | 21.43 | ab | 54.60 | a | 84.53 | b | 88.40 | a |
| $N_2B_2$ | 11.55 | a | 21.87 | a | 54.93 | a | 87.60 | a | 88.90 | a |
| $N_3B_0$ | 9.60 | bcd | 18.83 | de | 50.93 | ab | 83.33 | b | 82.97 | bc |
| $N_3B_1$ | 9.87 | bc | 20.83 | abc | 52.87 | ab | 82.87 | bc | 85.63 | ab |
| $N_3B_2$ | 10.37 | b | 20.87 | abc | 53.73 | ab | 84.20 | b | 88.03 | a |
| $LSD_{(0.05)}$ | 0.76 | | 1.58 | | 8.98 | | 2.05 | | 3.98 | |
| Significant level | * | | * | | * | | * | | * | |
| CV (%) | 5.63 | | 5.19 | | 10.61 | | 6.52 | | 5.05 | |

In a column means having similar letter(s) do not differ significantly as per DMRT

$N_0$ = without nitrogen, $N_1$ = 60 kg N/ha , $N_2$ = 120 kg N/ha , $N_3$ = 180 kg N/ha

$B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

**Plate 1:** Photograph showing the rapeseed grown with $N_0B_0$ (without N and B) at 50 days after sowing

**Plate 2:** Photograph showing the rapeseed grown with $N_2B_2$ treatment combination (120 kg N/ha and 2 kg B/ha) at 50 days after sowing

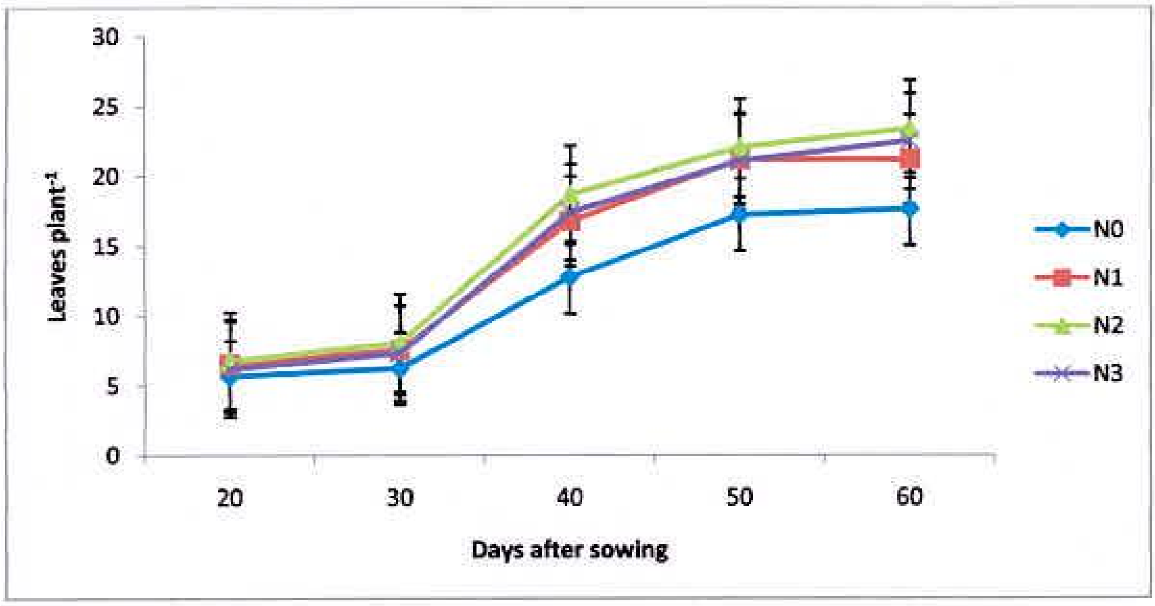


**Fig. 3:** Effect of N at different DAS on the number of leaves plant$^{-1}$ of rapeseed (DAS = Days after sowing, $N_0$ = without nitrogen, $N_1$ = 60 kg N /ha , $N_2$ = 120 kg N/ha , $N_3$ = 180 kg N/ha, Error bars represent standard deviation)

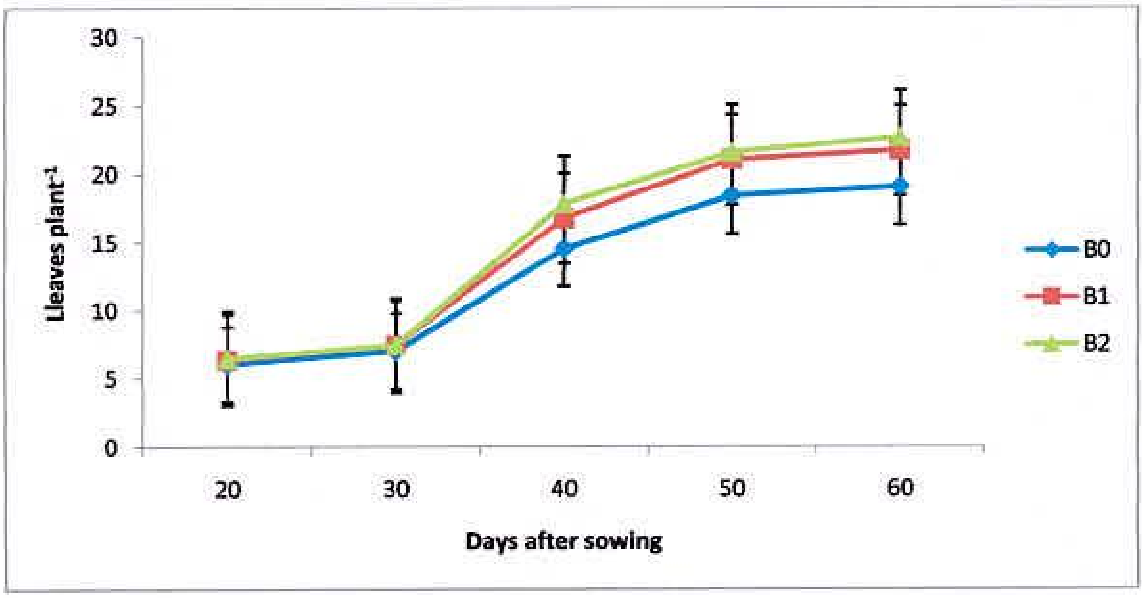


**Fig. 4:** Effect of different doses of B at different DAS on the number of leaves plant$^{-1}$ of rapeseed (DAS = Days after sowing, $B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha, Error bars represent standard deviation)

**Table 2.** Combined effect of N and B on the leaves plant-1 of rapeseed at different days after sowing (DAS)

| Treatment | Leaves plant-1 | | | | |
|---|---|---|---|---|---|
| | 20 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| $N_0B_0$ | 4.53 d | 5.40 e | 11.73 d | 16.47 e | 17.69 e |
| $N_0B_1$ | 6.20 bc | 6.67 d | 13.27 cd | 17.60 e | 17.60 e |
| $N_0B_2$ | 6.27 bc | 6.67 d | 13.33 cd | 17.67 e | 17.67 e |
| $N_1B_0$ | 6.50 abc | 7.33 bc | 15.13 bcd | 19.53 cde | 19.53 de |
| $N_1B_1$ | 6.80 abc | 7.27 bcd | 18.00 ab | 22.80 abc | 22.80 bc |
| $N_1B_2$ | 6.33 bc | 8.07 a | 17.20 bc | 21.20 abcd | 21.20 cd |
| $N_2B_0$ | 6.87 ab | 8.07 a | 15.87 bc | 19.67 bcde | 19.67 de |
| $N_2B_1$ | 6.33 bc | 7.87 ab | 18.27 ab | 21.87 abc | 23.53 bc |
| $N_2B_2$ | 7.12 a | 8.27 a | 21.87 a | 24.60 a | 26.93 a |
| $N_3B_0$ | 6.27 bc | 7.27 cd | 15.47 bcd | 18.13 de | 19.47 de |
| $N_3B_1$ | 6.13 c | 8.00 a | 17.67 b | 22.07 abc | 23.07 bc |
| $N_3B_2$ | 6.13 c | 6.77 cd | 19.07 ab | 23.00 ab | 25.00 ab |
| $LSD_{(0.05)}$ | 0.59 | 0.55 | 3.63 | 3.05 | 2.91 |
| Significant level | * | * | * | * | * |
| CV (%) | 9.06 | 11.51 | 13.05 | 8.84 | 8.12 |

In column, means bearing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

$N_0$ = without nitrogen, $N_1$ = 60 kg N/ha , $N_2$ = 120 kg N/ha , $N_3$ = 180 kg N/ha

$B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

was found in control treatment. These experimental results show that the combined use of N along with B can increase leaf number as well as leaf area of rapeseed plant.

### 4.3 Primary branches plant-1

The N showed significant variation in the number of branches per plant at 30, 40, 50 and 60 DAS (Fig. 5 and Appendix V). The maximum number of branches per plant (0.77, 5.43, 6.49 and 6.67 at 30, 40, 50 and 60 DAS, respectively) was produced by 120 kg N/ha. Control produced the minimum number of branches per plant (0.16, 2.98, 3.53 and 4.18 at 30, 40, 50 and 60 DAS, respectively). Mondal and Gaffer (1983) also reported that N fertilizer application had no significant effect on number of primary branches per plant of rapeseed, Tomar *et al.* (1996), Tomer *et al.* (1991), Ali and Ullah (1995) also obtained highest number of branch per plant with 120 kg N $ha^{-1}$. Altogether, it suggests that N involve in initiating primary branches by sprouting lateral buds of rapeseed plants.

The effect of B was no significantly influenced on number of branch per plant (Fig. 6 and Appendix V). The highest number of branches per plant (0.45, 4.73, 5.53 and 5.97 at 30, 40, 50 and 60 DAS, respectively) was obtained from $B_2$, 2 kg B/ha and the lowest number of branches per plant (0.38, 4.13, 5.07 and 5.43 at 30, 40, 50 and 60 DAS, respectively) was obtained from the control, $B_0$. It was observed that with the increase of B, number of branch per plant also increase a certain level.

The interaction between N and B was found significant on the number of primary branches per plant (Table 3 and Appendix V). The maximum number of branches per plant (1.17, 5.90, 7.02 and 7.40 at 20, 30, 40, 50 and 60 DAS, respectively) was found in $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B/ha whereas the lowest number of branches per plant (0.00, 2.80, 3.07, and 3.73 at 30, 40, 50 and 60 DAS respectively) was found in $N_0B_0$, control treatment, that are correlate with Murtaza and Paul (1989) findings, they observed significant effect of nitrogen on the number of primary branches $plant^{-1}$. Altogether, the result of this study suggests that N and B form together primary branches of rapeseed plants.

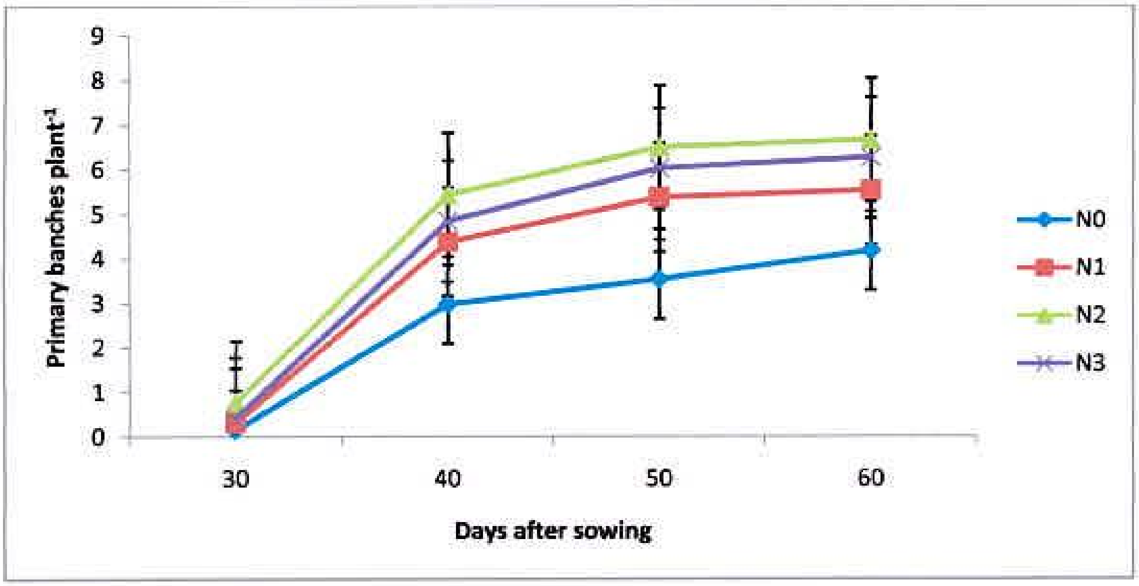


**Fig. 5:** Effect of N at different DAS on the primary branches plant$^{-1}$ of rapeseed (DAS = Days after sowing, $N_0$ = without nitrogen, $N_1$ = 60 kg N /ha , $N_2$ = 120 kg N/ha , $N_3$ = 180 kg N/ha, Error bars represent standard deviation)

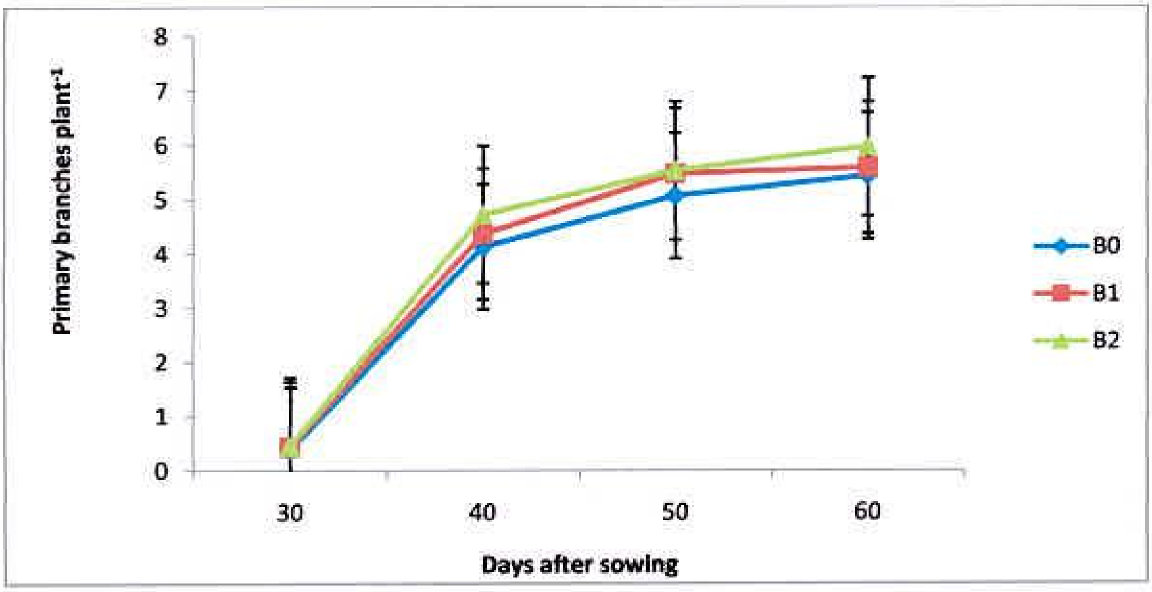


**Fig. 6:** Effect of different doses of B at different DAS on the primary branches plant$^{-1}$ of represent (DAS = Days after sowing, $B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha, Error bars represent standard deviation)

**Table 3.** Combined effect of N and B on the primary branches plant$^{-1}$ of rapeseed at different days after sowing (DAS)

| Treatment | Primary Branch plant$^{-1}$ | | | |
|---|---|---|---|---|
| | **30 DAS** | **40 DAS** | **50 DAS** | **60 DAS** |
| $N_0B_0$ | 0.00 b | 2.80 f | 3.07 e | 3.73 e |
| $N_0B_1$ | 0.33 b | 3.13 def | 4.33 cd | 4.40 de |
| $N_0B_2$ | 0.13 b | 3.00 ef | 3.20 de | 4.40 de |
| $N_1B_0$ | 0.13 b | 3.93 cdef | 4.53 c | 5.00 cde |
| $N_1B_1$ | 0.67 ab | 4.27 bcde | 5.53 bc | 5.53 bcd |
| $N_1B_2$ | 0.13 b | 4.93 abc | 6.07 ab | 6.07 abc |
| $N_2B_0$ | 0.70 ab | 5.60 ab | 6.47 ab | 6.60 ab |
| $N_2B_1$ | 0.43 b | 4.80 abc | 6.00 ab | 6.00 bc |
| $N_2B_2$ | 1.17 a | 5.90 a | 7.02 a | 7.40 a |
| $N_3B_0$ | 0.67 ab | 5.13 abc | 6.20 ab | 6.40 ab |
| $N_3B_1$ | 0.33 b | 4.33 bcd | 6.27 ab | 6.40 ab |
| $N_3B_2$ | 0.27 b | 5.07 abc | 5.60 bc | 6.00 bc |
| $LSD_{(0.05)}$ | 0.62 | 1.20 | 1.19 | 1.21 |
| CV (%) | 89.26 | 16.02 | 13.09 | 12.63 |

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

$N_0$ = without nitrogen, $N_1$ = 60 kg N/ha , $N_2$ = 120 kg N/ha , $N_3$ = 180 kg N/ha

$B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

### 4.4 Length of inflorescence

The N showed significant variation in the length of inflorescence (Fig. 7 and Appendix VI). The longest length of inflorescence (30.07, 31.04, 32.36 and 33.69 cm at 50, 60, 70 and 80 DAS, respectively) was produced by 120 kg N/ha whereas $N_2$ and $N_0$ treatment produced the shortest length of inflorescence (26.98, 28.89, 29.78 and 30.89 cm at 50, 60, 70 and 80 DAS, respectively).

There was no significant difference among the B treatments in the length of inflorescence (Fig. 8. and Appendix VI). As evident from fig 8, the maximum length of inflorescence (29.72, 31.28, 32.23 and 33.35 cm at 50, 60, 70 and 80 DAS, respectively) was produced from 2 kg B/ha. The minimum length of inflorescence (27.23, 29.03, 29.77 and 31.12 cm at 50, 60, 70 and 80 DAS, respectively) was produced in control.

The analysis of variance (Table 4 and Appendix VI) indicated a significant variation among the treatment combinations in length of inflorescence. The maximum length of inflorescence (31.80, 32.27, 34.27 and 35.67 cm at 50, 60, 70 and 80 DAS, respectively) was found in $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B/ha whereas the minimum length of inflorescence (24.93, 26.80, 28.07 and 30.00 cm at 50, 60, 70 and 80 DAS, respectively) was found in control (Table 4).

### 4.5 Siliquae plant$^{-1}$

Number of siliquae plant$^{-1}$ is one of the most important yield contributing characters in rapeseed. The N showed significant variation in the number of siliquae plant$^{-1}$ (Table 5 and Appendix VII). The maximum number of siliquae plant$^{-1}$ (26.09) was produced by $N_2$, 120 kg N/ha and $N_0$ produced the minimum number of siliquae plant$^{-1}$ (22.24). Similar result also obtained by Shukla et al. (2002), Shing et al. (2003) in rapeseed. These are consistent with the length of inflorescence of rapeseed (Fig. 7).

There was a significant difference among the B in the number of siliquae plant$^{-1}$ (Table 6 and Appendix VII). The maximum number of siliquae plant$^{-1}$ (25.43) was produced in $B_2$ or with 2 kg B/ha and the minimum number of siliquae plant$^{-1}$ (22.80) was produced in $B_0$ or control condition. These results are in conformity with those of Islam and Sharker (1993), Dutta and Uddin (1983) and Dutta et al. (1984), who have observed increased number of siliquae plant$^{-1}$ of rapeseed by increasing rate of B.

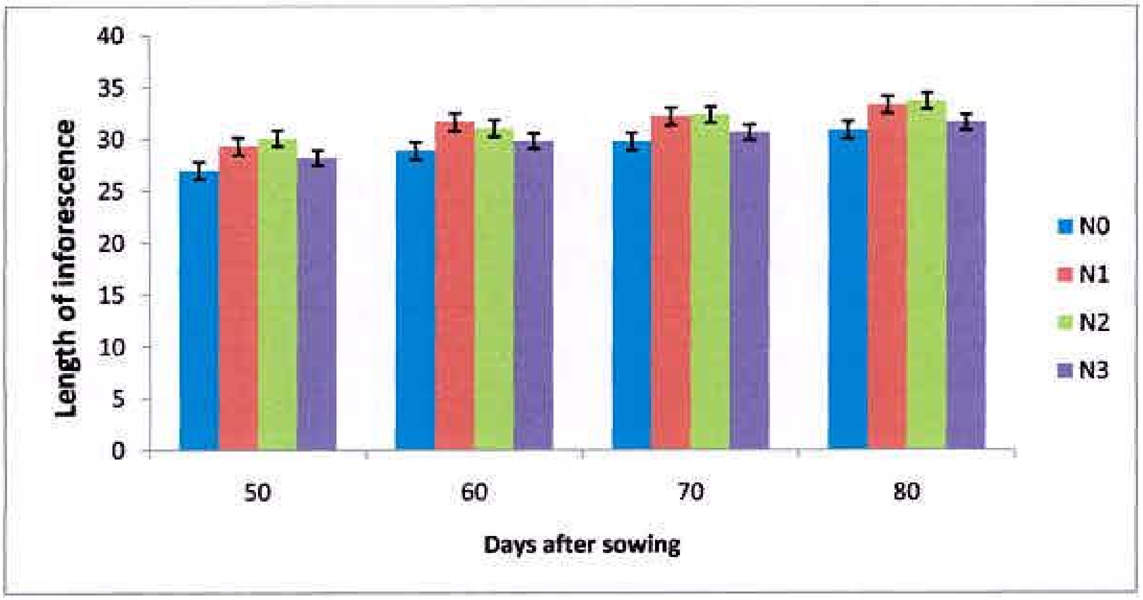


**Fig. 7:** Effect of N at different DAS on length of inflorescence plant$^{-1}$ of rapeseed (DAS = Days after sowing, $N_0$ = without nitrogen, $N_1$ = 60 kg N /ha, $N_2$ = 120 kg N/ha, $N_3$ = 180 kg N/ha, Error bars represent standard deviation)

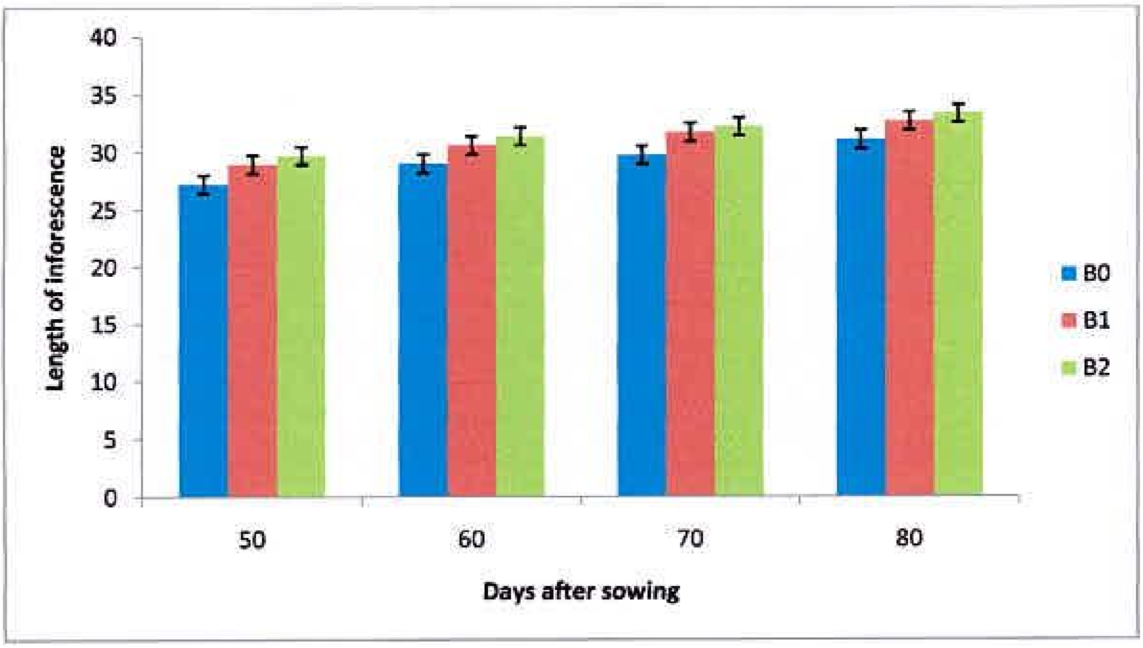


**Fig. 8:** Effect of different doses of B at different DAS on the length of inflorescence plant$^{-1}$ of rapeseed (DAS = Days after sowing, $B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha, Error bars represent standard deviation)

**Table 4.** Interaction effect of N and B on length of inflorescence of rapeseed at different days after sowing (DAS)

| Treatment | Length of inflorescence (cm) | | | |
|---|---|---|---|---|
| | **50 DAS** | **60 DAS** | **70 DAS** | **80 DAS** |
| $N_0B_0$ | 24.93 c | 26.80 b | 28.07 c | 30.00 c |
| $N_0B_1$ | 28.87 abc | 31.07 ab | 31.80 abc | 32.20 abc |
| $N_0B_2$ | 27.13 abc | 28.80 ab | 29.47 bc | 30.47 bc |
| $N_1B_0$ | 28.27 abc | 30.60 ab | 30.93 abc | 32.00 abc |
| $N_1B_1$ | 29.37 abc | 31.53 a | 33.00 ab | 34.07 ab |
| $N_1B_2$ | 30.33 ab | 32.07 a | 32.67 ab | 33.87 abc |
| $N_2B_0$ | 29.07 abc | 29.73 ab | 30.60 abc | 32.20 abc |
| $N_2B_1$ | 29.33 abc | 31.87 a | 32.40 ab | 33.20 abc |
| $N_2B_2$ | 31.80 a | 32.27 a | 34.07 a | 35.67 a |
| $N_3B_0$ | 26.67 bc | 29.00 ab | 29.47 bc | 30.27 bc |
| $N_3B_1$ | 28.30 abc | 30.33 ab | 31.73 abc | 31.33 bc |
| $N_3B_2$ | 29.60 abc | 30.07 ab | 30.73 abc | 33.40 abc |
| $LSD_{(0.05)}$ | 4.38 | 3.79 | 3.40 | 3.48 |
| Significant level | * | * | * | * |
| CV (%) | 9.03 | 7.38 | 6.43 | 0.06 |

In column, means having same letter indicate statistically similar under DMRT at 5% level of significance. Values are the means of three replications

$N_0$ = without nitrogen, $N_1$ = 60 kg N/ha , $N_2$ = 120 kg N/ha , $N_3$ = 180 kg N/ha

$B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

Interestingly, the number of siliquae per plant is inconsistent or dissimilar with length of inflorescence in rapeseed to B (Fig. 8).

siliquae plant$^{-1}$ varied markedly among different treatment combination (Table 7 and Appendix VII). The maximum number of siliquae per plant (27.42) was found in $N_2B_2$, whereas the minimum number of siliquae per plant (20.60) was found in $N_0B_0$ treatment combination. These results are consistent with the results of length of inflorescence up to 80 DAS (Table 4).

**4.6 Seed weight of 100 siliquae**

The N showed significant variation in the seed weight of 100 siliquae (Table 5 and Appendix VII). The maximum seed weight of 100 siliquae (10.67 g) was produced by $N_2$ treatment, which was statistically similar with $N_1$ and $N_3$ whereas $N_0$ produced the minimum seed weight of 100 siliquae (8.24 g).

There was a significant difference among the B fertilizer in the seed weight of 100 siliquae (Table 6 and Appendix VII). The maximum seed weight of 100 silliquae (10.43g) was produced in $B_2$, 2 kg B/ha. The minimum seed weight of 100 siliquae (8.96 g) was produced in $B_0$ or without B.

Seed weight of 100 siliquae indicated a significant variation among the treatment combinations of N and B (Table 7 and Appendix VII). The maximum seed weight of 100 siliquae (11.93 g) was found in $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B /ha, whereas the minimum seed weight of 100 siliquae (6.82g) was found in control, $N_0B_0$ treatment combination. These results indicate that the combined use of N and B has strong role on increasing the seed weight of 100 siliquae other than N and B along.

#### 4.7 Seed weight plant-1

The N showed significant variation in the seed weight plant$^{-1}$ (Table 5 and Appendix VII). The maximum seed weight plant$^{-1}$ (5.40 g) was produced by $N_2$, which was statistically similar with $N_1$ and $N_3$ whereas $N_0$ produced the minimum seed weight plant$^{-1}$ (3.14 g). Seed weight increased with the increasing rates of N fertilizer up to 120 kg/ha and then declined. These obtained results are similar with the finding of seed weight of 100 siliquae (Table 5). The higher seed weight plant$^{-1}$ was also obtained with same N rate as reported by Singh *et al.* (1998), Tateja *et al.* (1996).

There was a significant difference in the seed weight plant$^{-1}$ (Table 6 and Appendix VII). The maximum seed weight plant$^{-1}$ (5.21 g) was produced in $B_2$ treatment. The minimum seed weight plant$^{-1}$ (3.57 g) was produced in without B condition that is similar with the findings of Islam and Sarkar (1993), they reported that application of B increased significantly the number of siliquae plant$^{-1}$, no. of seeds siliqua$^{-1}$ and seed weight of rapeseed. These results are also similar with the results of seed weight of 100 siliquae (Table 6).

Seed weight plant$^{-1}$ indicated a significant variation among the treatment combinations of N and B (Table 7 and Appendix VII). The maximum seed weight plant$^{-1}$ (6.48 g) was found in $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B /ha, whereas the minimum seed weight plant$^{-1}$ (2.03 g) was found in $N_0B_0$ treatment, which is consistent with the seed weight of 100 siliquae (Table 7).

#### 4.8 Thousand seed weight (g)

N did influence significantly on the thousand seed weight (Table 5 and Appendix VII). The maximum thousand seed weight (4.46 g) was produced by $N_2$, which was statistically similar with $N_1$ and $N_3$ treatment and $N_0$ produced the lowest thousand seed weight (3.21 g). Ozer (2003), Singh *et al.* (2002) and Shamsuddin et al. (1987) also obtained highest 1000 seed weight with 120 kg N/ha.

The weight of thousand seed was significantly influenced by B (Table 6 and Appendix VII). The highest thousand seed weight (4.15 g) was obtained from $B_2$ treatment. The lowest thousand seed weight (3.56 g) was obtained from without B.

Thousand seed weight was significantly affected by both N and B (Table 7 and Appendix VII). The highest thousand seed weight (5.07 g) was found in $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B /ha whereas the lowest thousand seed weight (2.91 g) was found in $N_0B_0$ treatment (Table 7). These results suggest that combined use of appropriate doses of N and B produced maximum thousand seed weight than the use of same dose of N or B along.

**4.9 Seed yield (t/ha)**

The seed yield of rapeseed per plot was converted into per hectare, and has been expressed in metric tons (Table 5 and Appendix VII). The different dose of N had significant effect on the yield of seed per hectare. The maximum yield of seed per hectare (1.50 t) was obtained from $N_{2,}$ 120 kg N/ha, whereas the minimum yield of seed per hectare (0.99 t) was obtained from $N_{0,}$ without N. Further increase in N level beyond 120 kg/ha could not improve the seed yield. These results is consistent with the N-induced increase of growth parameters (Fig. 1, 3, 5, 7) along with number of siliquae/plant, seed weight of 100 siliqua, seed weight /plant and thousand seed weight (Table 5). The higher seed yield/ha was also obtained with same N rate reported by Sing and Prasad (2003), Singh *et al.* (2003), Shukla *et al.* (2002). Therefore, N can enhance the seed yield (t/ha) of rapeseed variety BARI sarisha 14.

The total yield of rapeseed varied significantly due to the application of different levels of B fertilizer (Table 6 and Appendix VII). The highest yield of seed (1.47 t/ha) was obtained from $B_{2,}$ 2 kg B/ha while $B_0$ gave the lowest (1.04 t/ha) yield. This result showed that the yield of mustard increased gradually with the higher doses of B fertilizer. Sakal et al. (1991), Sinha et al. (1991), Banuels et al. (1990), obtained a similar result by applying 1 to 2 kg B/ha. Malewar (2001) found that seed yield significantly increased with each levels of B. Interestingly, this result is consistent with the B-induced yield components such as number of siliqua /plant, seed weight of 100 siliqua, seed weight / plant, thousand seed weight, seed yield and harvest index (Table 6) rather than growth parameters (Fig. 2, 4, 6, 8). Therefore, higher dose of B can increase seed yield of rapeseed.

The combined effect of N and B fertilizer was significant on yield of seed per hectare (Table 7 and Appendix VII). The highest yield of seed per hectare (1.78 tones) was obtained from $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B /ha. The lowest yield of seed per hectare (0.92 tones) was obtained from $N_0B_0$ treatment.

**4.10 Harvest index (%)**

The different N had significant effect on the harvest index of mustard (Table 5 and Appendix VII). The maximum harvest index (55.24 %) was obtained with $N_2$, 120 kg N/ha and the minimum harvest index (48.73 %) was obtained from $N_0$ treatment (Table 7). Shrivastava *et al.* (1988) found a similar result in their experiment.

The harvest index varied significantly due to the application of different levels of B fertilizer (Table 6 and Appendix VII). The highest harvest index (52.99 %) was obtained from $B_2$, 2 kg B/ha while $B_0$ gave the lowest (50.62 %) harvest index (Table 8). Mahajan et al. (1994) found higher harvest index due to B application.

The combined effect of N and B fertilizer was significant on harvest index (table 7 and Appendix VII). The highest harvest index (57.54 %) was obtained from $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B /ha. The lowest harvest index (46.27 %) was obtained from control treatment.

**Table 5.** The effect of N on yield contributing character and yield of rapeseed

| Treatment | Siliqua plant$^{-1}$ | Seed weight of 100 siliquae (g) | Seed weight plant$^{-1}$ (g) | 1000 seed weight (g) | Seed yield (t/ha) | Harvest Index (%) |
|---|---|---|---|---|---|---|
| $N_0$ | 22.24 b | 8.24 b | 3.14 b | 3.21 b | 0.99 b | 48.73 b |
| $N_1$ | 23.51 ab | 10.45 a | 4.33 a | 4.11 a | 1.22 ab | 50.76 b |
| $N_2$ | 26.09 a | 10.67 a | 5.40 a | 4.46 a | 1.50 a | 55.24 a |
| $N_3$ | 24.67 ab | 9.91 a | 4.82 a | 3.97 a | 1.36 ab | 52.59 ab |
| $LSD_{(0.05)}$ | 3.25 | 1.11 | 1.14 | 0.75 | 0.39 | 4.03 |
| Significant level | * | * | * | * | * | * |
| CV (%) | 8.85 | 14.34 | 20.11 | 15.71 | 11.68 | 8.05 |

**Table 6.** Effect of B on yield contributing character and yield of rapeseed

| Treatment | Siliqua plant-1 | Seed weight of 100 siliquae (g)) | Seed weight plant-1 (g) | 1000 seed weight (g) | Seed yield (t/ha) | Harvest Index (%) |
|---|---|---|---|---|---|---|
| $B_0$ | 22.8 b | 8.96 b | 3.57 b | 3.56 b | 1.04 b | 50.62 b |
| $B_1$ | 24.15 ab | 10.06 a | 4.49 ab | 4.13 a | 1.30 ab | 51.89 ab |
| $B_2$ | 25.43 a | 10.43 a | 5.21 a | 4.15 a | 1.47 a | 52.99 a |
| $LSD_{(0.05)}$ | 2.12 | 1.01 | 1.54 | 0.53 | 0.04 | 2.23 |
| Significant level | * | * | * | * | * | * |
| CV (%) | 8.85 | 14.34 | 20.11 | 15.71 | 4.91 | 8.05 |

**Table 7.** Interaction effect of N and B on yield contributing characters, yield and harvest index of rapeseed

| Treatment | No. of siliqua/plant | Seed weight of 100 siliquae (g)) | Seed weight/plant (g) | 1000 seed weight (g) | Seed yield (t/ha) | Harvest Index (%) |
|---|---|---|---|---|---|---|
| $N_0B_0$ | 20.60 d | 6.82 c | 2.03 d | 2.91 d | 0.92 f | 46.27 b |
| $N_0B_1$ | 22.80 bcd | 8.62 bc | 3.46 cd | 3.53 bcd | 0.96 f | 49.52 ab |
| $N_0B_2$ | 23.33 abcd | 9.28 abc | 3.92 c | 3.18 cd | 1.10 ef | 50.40 ab |
| $N_1B_0$ | 20.80 cd | 10.79 ab | 3.61 cd | 3.90 ad | 0.98 f | 51.32 ab |
| $N_1B_1$ | 24.80 abc | 10.99 ab | 4.68 bc | 4.40 ab | 1.26 cde | 50.61 ab |
| $N_1B_2$ | 24.93 abc | 9.58 ab | 4.71 bc | 4.04 a-d | 1.41 bcd | 50.34 ab |
| $N_2B_0$ | 26.53 ab | 9.39 abc | 4.83 abc | 3.89 abcd | 1.20 def | 53.32 ab |
| $N_2B_1$ | 24.27 abcd | 10.69 ab | 4.90 abc | 4.43 ab | 1.52 abc | 54.86 a |
| $N_2B_2$ | 27.47 a | 11.93 a | 6.48 a | 5.07 a | 1.78 a | 57.54 a |
| $N_3B_0$ | 23.27 bcd | 8.84 bc | 3.82 c | 3.55 bcd | 1.04 ef | 51.55 ab |
| $N_3B_1$ | 24.73 abc | 10.18 ab | 4.93 abc | 4.17 abc | 1.45 bcd | 52.56 ab |
| $N_3B_2$ | 26.00 ab | 10.71 ab | 5.71 ab | 4.20 abc | 1.58 ab | 53.66 ab |
| $LSD_{(0.05)}$ | 3.62 | 2.38 | 1.51 | 1.05 | 0.25 | 6.98 |
| Significant level | * | * | * | * | * | * |
| CV (%) | 8.85 | 14.34 | 20.11 | 15.71 | 11.68 | 8.05 |

**4.11 Oil content (%)**

In this study oil content show significant influence by different N levels (Fig. 9 and Appendix VII). Fig. 9 revealed that application of N at 120 kg/ha ($N_2$) gave the maximum oil content (42.82 %) and the minimum oil content (42.30 %) was obtained from $N_0$ levels. Singh et al. (2004) also reported that N application did not affect the oil content of rapeseed. The present results of oil content of rapeseed suggest that N improve the oil percent up to 120 kg N /ha but not 180 kg /ha.

The oil content varied significantly due to the application of different levels of B fertilizer (Fig. 10 and Appendix VII). The highest oil content (42.82 %) was obtained from $B_2$, 2 kg B/ha while $B_0$ gave the lowest (42.33 %) oil content. These results suggest that B can synthesis oil in rapeseed and higher levels of B improve the percent of oil in rapeseed.

The combined effect of N and B fertilizer was significant on oil content of rapeseed (Table 8 and Appendix VII). The highest oil content (42.96 %) was obtained from $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B/ha whereas the lowest oil content (41.39 %) was obtained from $N_2B_2$ treatment combination, 120 kg N/ha and 2 kg B /ha (Table 8). Present result of oil content of rapeseed indicate that the combined use of N and B can enhance the percent of rapeseed oil content as compared to N and B alone (Fig. 9,10, Table 8). Therefore, it can be suggested that the 120 kg N/ha along with 2 kg B/ha is the best combination for containing higher amount of oil percent in rapeseed.

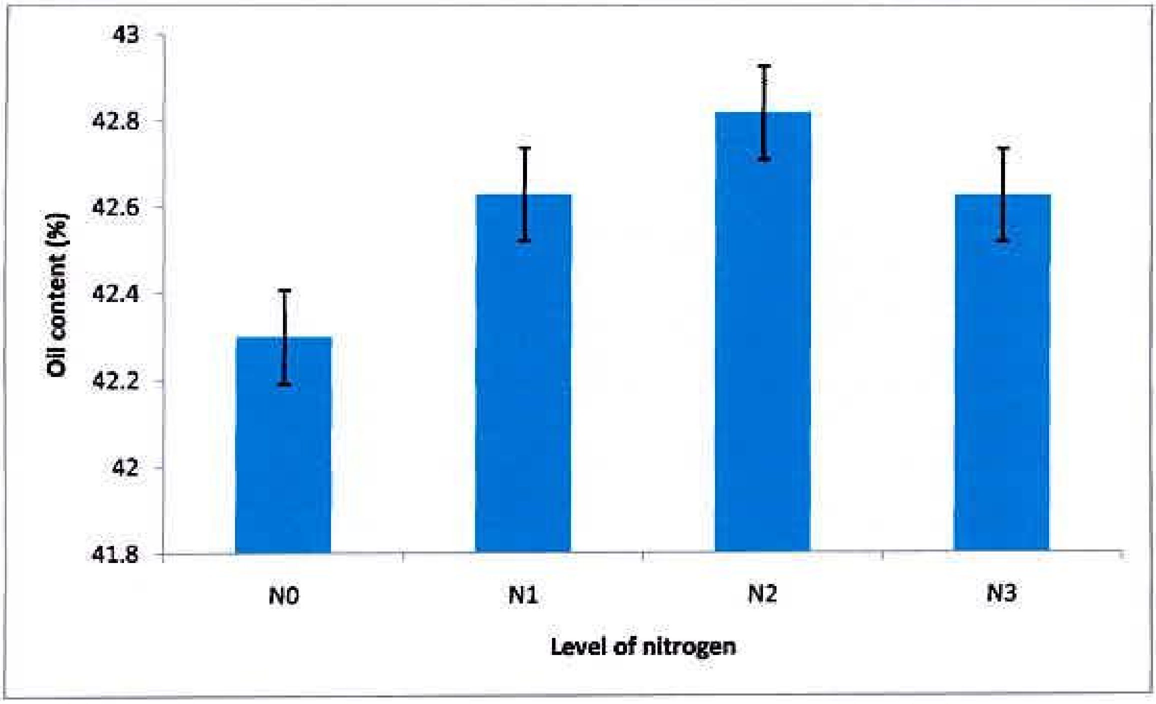


**Fig. 9:** The effect of N on oil content of rapeseed ($N_0$ = without nitrogen, $N_1$ = 60 kg N /ha, $N_2$ = 120 kg N/ha , $N_3$ = 180 kg N/ha, Error bars represent standard deviation)

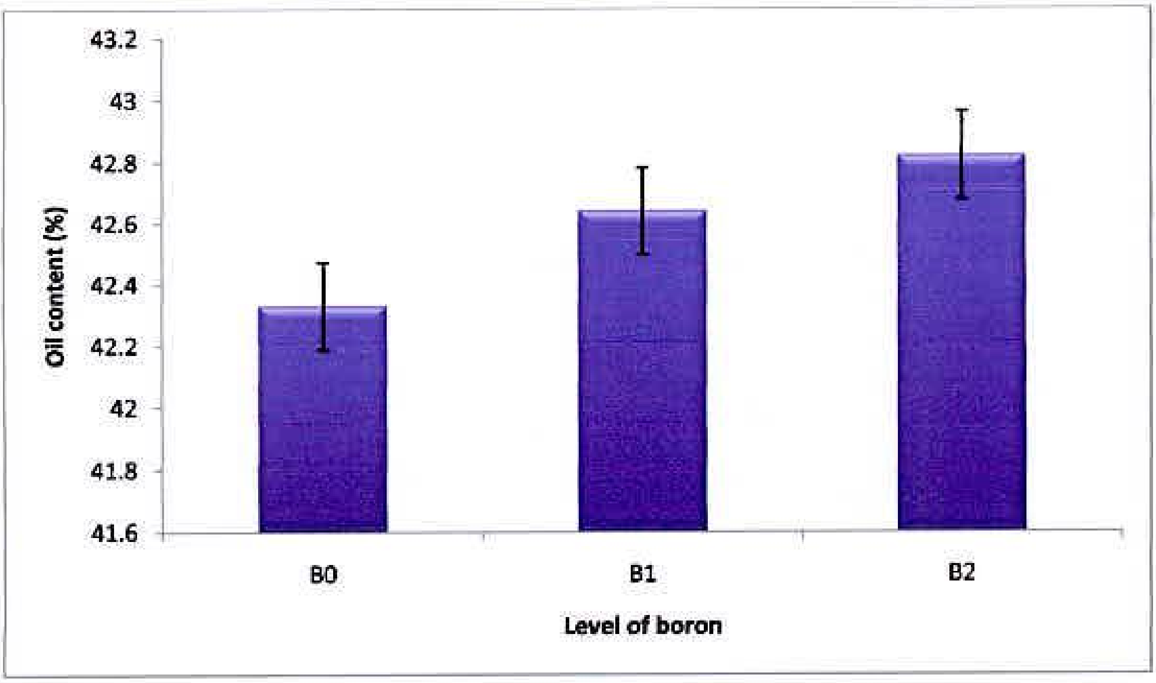


**Fig. 10:** The effect of B on oil content of rapeseed ($B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha, Error bars represent standard deviation)

**Table 8.** Interaction effect of N and B on oil content and germination percentage of rapeseed

| Treatment | Oil content (%) | Germination (%) |
|---|---|---|
| $N_0B_0$ | 41.39 e | 94.67 a |
| $N_0B_1$ | 42.77 abc | 93.67 a |
| $N_0B_2$ | 42.74 abc | 92.00 a |
| $N_1B_0$ | 42.57 bcd | 94.33 a |
| $N_1B_1$ | 42.87 ab | 93.67 a |
| $N_1B_2$ | 42.43 d | 93.33 a |
| $N_2B_0$ | 42.43 d | 93.67 a |
| $N_2B_1$ | 42.51 cd | 93.33 a |
| $N_2B_2$ | 42.96 a | 91.33 a |
| $N_3B_0$ | 42.91 a | 94.00 a |
| $N_3B_1$ | 42.69 abcd | 93.67 a |
| $N_3B_2$ | 42.86 ab | 93.00 a |
| $LSD_{(0.05)}$ | 0.27 | 3.12 |
| Significant level | * | NS |
| CV (%) | 25.00 | 6.66 |

In column, means containing same letter indicate statistically similar under DMRT at 5% level of significance. Values are the means of three replications

$N_0$ = without nitrogen, $N_1$ = 60 kg N/ha, $N_2$ = 120 kg N/ha, $N_3$ = 180 kg N/ha

$B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

NS= Non Significant

### 4.12 Germination percentage

The germination percentage of seed was not significantly affected of this rapeseed variety (Fig. 11 and Appendix VII). The maximum germination percentage of seed (93.78 %) was obtained from $N_1$ (60 kg N/ha) whereas the minimum germination percentage of seed (92.78 %) was obtained with $N_2$ (120 kg N/ha). Similarly, germination percentage of seed was not influenced by B (Fig. 12 and Appendix VII). The maximum germination percentage of seed (94.17 %) was obtained from $B_0$ (control) and the minimum (92.42 %) from $B_2$ (2 kg B/ha). Again, interaction effect of N and B also had no significant variation on germination percentage of seed (Table 8 and Appendix VII). The maximum germination percentage of seed (94.67 %) was obtained from $N_0B_0$, while the shortest (91.33 %) was obtained from $N_2B_2$ (Table 8). So, there is no significant difference among the different level of N and B in respect of germination percentage of seed. The combination of N and B levels also had no significant effect on this parameter. Therefore, it suggests that N and B have no prominent function on germination of seed either independently or combinedly.

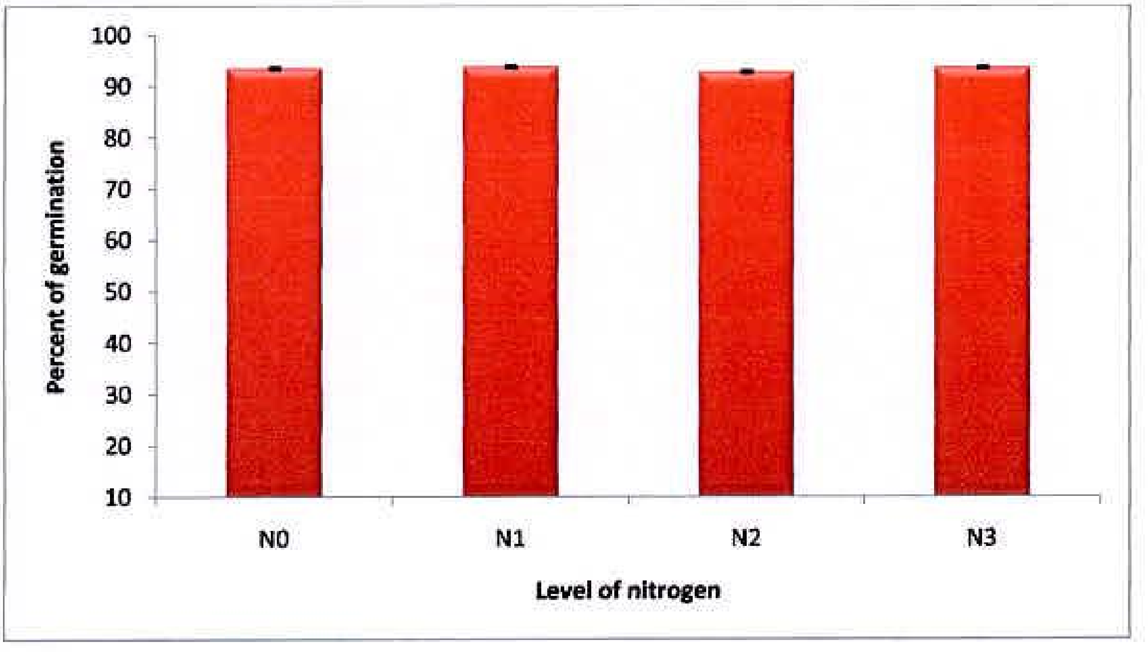


**Fig. 11.** The effect of N on germination percentage of rapeseed ($N_0$ = without nitrogen, $N_1$ = 60 kg N /ha, $N_2$ = 120 kg N/ha, $N_3$ = 180 kg N/ha, Error bars represent standard deviation)

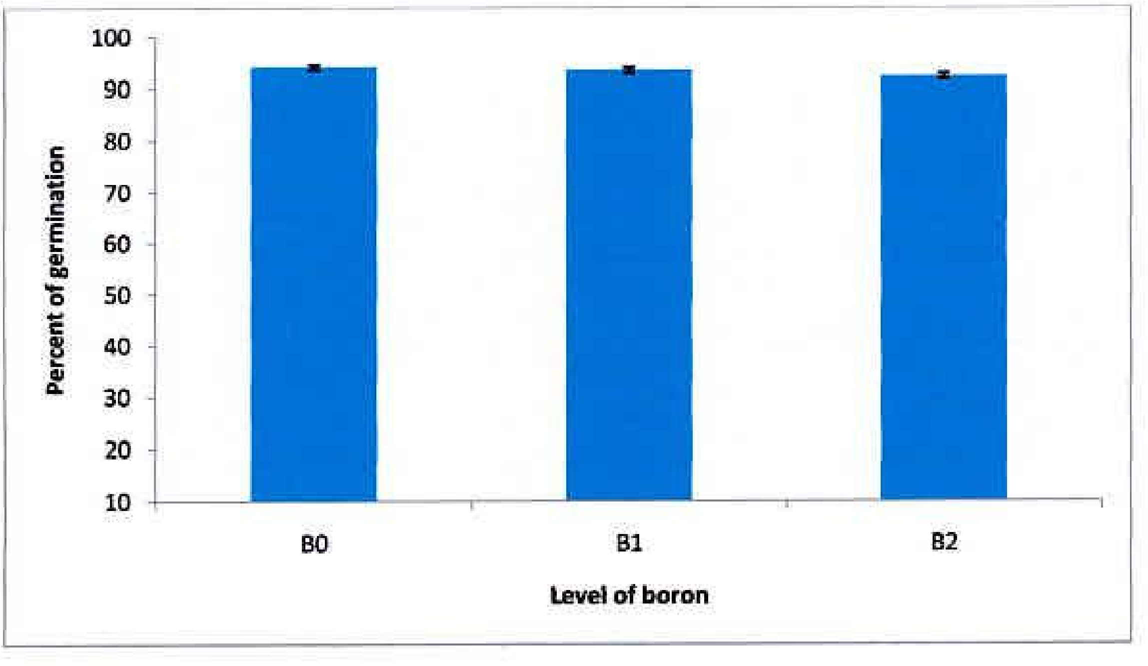


**Fig. 12.** The effect of B on germination percentage of rapeseed ($B_0$ = without boron, $B_1$ = 1 kg B/ha, $B_2$ = 2 kg B/ha, Error bars represent standard deviation)

# Chapter 5
# Summary and Conclusion

# Chapter 5

# SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the rabi season from November 2011 to February 2012 to study on growth, yield and seed quality of rapeseed as influenced by N and B. In this experiment, the treatment consisted of four different N levels viz. $N_0$ = 0 (kg N/ha), $N_1$ = 60 (kg N/ha), $N_2$ = 120 (kg N/ha) and $N_3$= 180 (kg N/ha), and three different level of B viz. $B_0$ = 0 (kg B/ha), $B_1$= 1 (kg B/ha), $B_2$= 2 (kg B/ha). The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The amount of fertilizers in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid as a source of N, P, K, S, Zn and B respectively were applied according to treatment and area of experimental unit plot. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect majority of the observed parameters.

There is significant difference among the different levels of N in respect of almost all parameters. The tallest plant (10.37, 20.77, 54.36, 85.18 and 87.46 cm at 20, 30, 40, 50 and 60 DAS respectively) was recorded with $N_{2,}$ 120 kg N/ha. The maximum number of leaves plant$^{-1}$ (6.77, 8.07, 18.67, 22.04 and 23.38 at 20, 30, 40, 50 and 60 DAS, respectively), number of branches plant$^{-1}$ (0.77, 5.43, 6.49 and 6.67 at 30, 40, 50 and 60 DAS, respectively), length of inflorescence (30.07, 31.04, 32.36 and 33.69 cm at 50, 60, 70 and 80 DAS, respectively) were produced with $N_{2,}$ 120 kg N/ha. The maximum number of siliquae plant$^{-1}$ (26.09), seed weight of 100 siliquae (10.67 g), seed weight plant$^{-1}$ (5.40 g), thousand seed weight (4.46 g) were produced with $N_{2,}$ 120 kg N/ha. The maximum yield of seed ha$^{-1}$ (1.50 t) and harvest index (55.24 %) was obtained with $N_{2,}$ 120 kg N/ha and the minimum yield of seed ha$^{-1}$ (0.99 t) and harvest index (48.73 %) was obtained with $N_0$ (control). The highest rapeseed oil content (42.82 %) was obtained with $N_2$, 120 kg N/ha whereas the percent of germination did not show any effect with increasing or decreasing rate of N.

Plant height, leaves plant$^{-1}$, branches plant$^{-1}$ and length of inflorescence did not show any statistical difference in response of application of B. However, the tallest plant of rapeseed (10.10, 19.86, 51.73, 81.43 and 83.61 cm at 20, 30, 40, 50 and 60 DAS, respectively) was produced with $B_2$, 2 kg B/ha. The maximum number of leaves plant$^{-1}$ (6.46, 7.45, 17.87, 21.62 and 22.70 cm at 20, 30, 40, 50 and 60 DAS, respectively), number of branches plant$^{-1}$ (0.45, 4.73, 5.53, 5.97 at 30, 40, 50 and 60 DAS, respectively), length of inflorescence (29.72, 31.28, 32.23 and 33.35 cm at 50, 60, 70 and 80 DAS, respectively) was produced with $B_2$, 2 kg B/ha. Interestingly, statistically the maximum number of siliquae plant$^{-1}$ (25.43), seed weight of 100 siliquae (10.43 g), seed weight plant$^{-1}$ (5.21 g), thousand seed weight (4.15 g) was produced in $B_2$, 2 kg B/ha. The highest yield of seed (1.47 t/ha) and harvest index (52.99 %) was obtained from $B_2$, while $B_0$ gave the lowest (1.04 t/ha) seed yield and harvest index (50.62 %) of rapeseed. The maximum seed oil content (42.82 %) and minimum seed oil content (42.33 %) was obtained from $B_2$, 2 kg B/ha and $B_0$ or without B condition respectively. Separately, B failed to change the germination percentage of rapeseed.

The combinations of N and B had significant effect on almost all parameter. The tallest plant (11.55, 21.87, 54.93, 87.60 and 88.90 cm at 20, 30, 40, 50 and 60 DAS, respectively) was found in $N_2B_2$ treatment combination, 120 kg N/ha with 2 kg B/ha. The maximum number of leaves plant$^{-1}$ (7.12, 8.27, 21.87, 24.60 and 26.93 at 20, 30, 40, 50 and 60 DAS, respectively), number of branches plant$^{-1}$ (1.17, 5.90, 7.02 and 7.40 at 20, 30, 40, 50 and 60 DAS, respectively) and length of inflorescence (31.80, 32.27, 34.27 and 35.67 cm at 50, 60, 70 and 80 DAS, respectively) was found in $N_2B_2$ treatment combination, 120 kg N/ha with 2 kg B/ha. The maximum number of siliquae plant$^{-1}$ (27.47), seed weight of 100 siliquae (11.93 g), seed weight plant$^{-1}$ (6.48 g) and thousand seed weight (5.07 g) was found in $N_2B_2$, 120 kg N/ha with 2 kg B/ha. The highest yield of seed ha$^{-1}$ (1.78 t) was obtained from $N_2B_2$ treatment combination. The lowest yield of seed ha$^{-1}$ (0.92 t) was obtained from $N_0B_0$ treatment combination or control. The highest harvest index (57.54 %) and lowest harvest index (50.62 %) was recorded at $N_2B_2$ and $N_0B_0$ treatment combination respectively. The $N_2B_2$ treatment combination showed the highest seed oil content of rapeseed (42.96 %) and $N_0B_0$ showed the lowest amount of oil content (41.39 %). Interestingly, the interaction of N and B did not exhibit statistical effect to change the germination percent of rapeseed.

Considering the above results, it may be summarized that growth, seed yield and oil content contributing parameters of rapeseed are positively correlated with N and B application. Therefore, the present experimental results suggest that the combined use of 120 kg N/ha and 2 kg B/ha along with recommended doses of other fertilizer whould be beneficial to increase the seed yield and oil content of rapeseed variety BARI sarisha 14 under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. The results are required to substantiate further with different varieties of rapeseed and mustard.
3. It needs to conduct more experiments with N and micronutrient Zn whether can regulate the growth, yield and seed quality of rapeseed BARI sarisha 14.

# Chapter 6
# References

# Chapter 6

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# Chapter 7
# Appendices

# Chapter 7

# APPENDICES

## Appendix I: Physical and chemical characteristics of initial soil (0-15 cm depth)

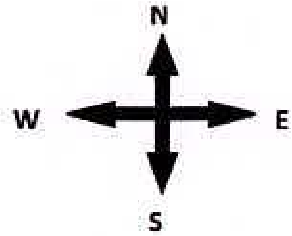
### A. Physical composition of soil

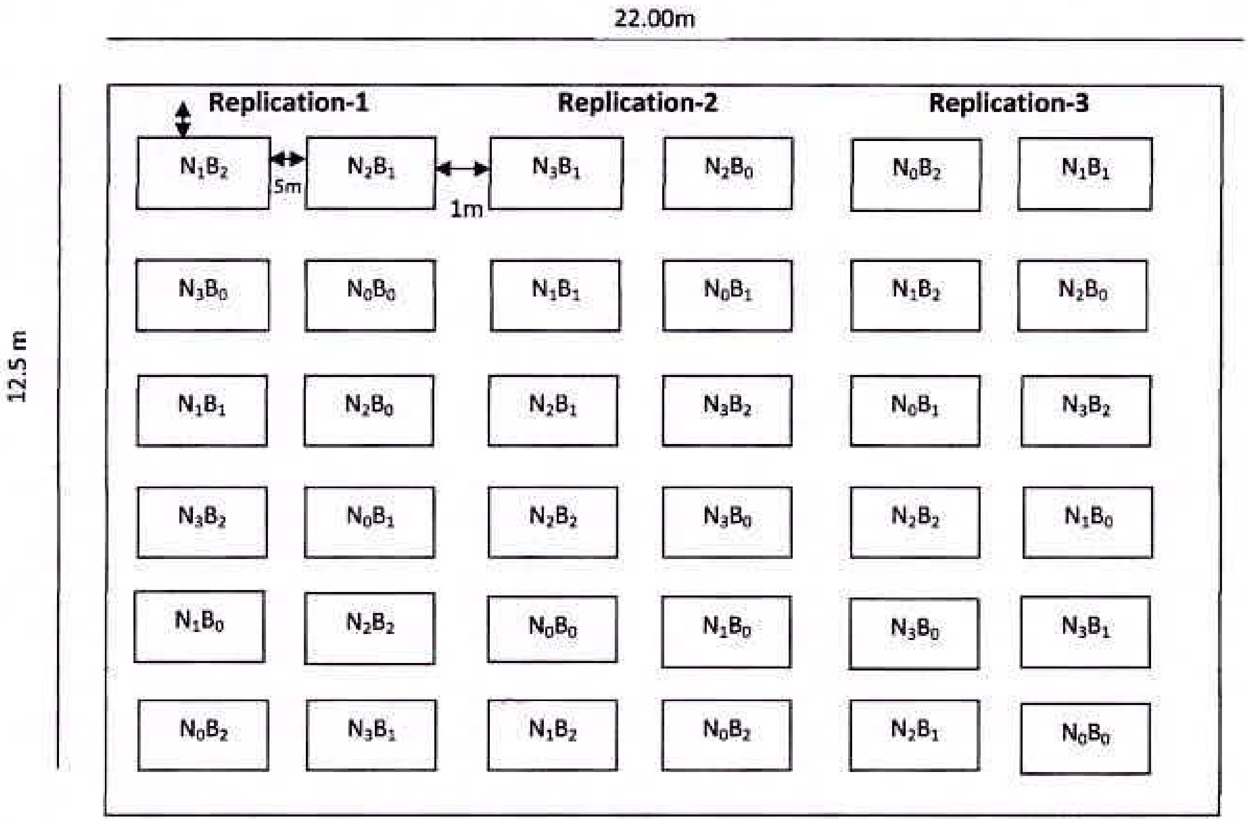
| Soil separates | (%) | Methods employed |
|---|---|---|
| Sand | 36.90 | Hydrometer method (Day, 1995) |
| Silt | 26.40 | -do- |
| Clay | 36.66 | -do- |
| Texure class | Clay loam | -do- |

### B. Chemical composition of soil

| SI. | Soil characteristics | Analytical data | Methods employed |
|---|---|---|---|
| 1 | Organic carbon (%) | 0.82 | Walkley and Black, 1947 |
| 2 | Total N (kg/ha) | 1790.00 | Bremner and Mulvaney, 1965 |
| 3 | Total S (ppm) | 225.00 | Bardsley and Lancster, 1965 |
| 4 | Total P (ppm) | 840.00 | Olsen and Sommers, 1982 |
| 5 | Available N (kg/ha) | 54.00 | Bremner, 1965 |
| 6 | Available P (kg/ha) | 69.00 | Olsen and Dean, 1965 |
| 7 | Exchangeable K (kg/ha) | 89.50 | Pratt, 1965 |
| 8 | Available S (ppm) | 16.00 | Hunter, 1984 |
| 9 | PH (1:2.5 soil to water) | 5.55 | Jackson,1958 |
| 10 | CEC | 11.23 | Chapman, 1965 |

**Appendix II. Layout of the experimental plot**




| Unit plot size: | Factor A: Nitrogen | Factor B: Boron |
|---|---|---|
| 3 m x 1.5 m | $N_0$= without nitrogen | $B_0$= without boron |
| N = Nitrogen | $N_1$=60 kg N/ha | $B_1$=1 kg B/ha |
| B= Boron | $N_2$=120 kg N/ha | $B_2$=2 kg B/ha |
| | $N_3$=180 kg N/ha | |

**Appendix III: Analysis of variance of the data on plant height of rapeseed as influenced by different level of nitrogen and boron**

| Sources of Variation | Degrees of freedom | Mean Square | | | | |
|---|---|---|---|---|---|---|
| | | Plant Height | | | | |
| | | 20 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 0.13 | 1.462 | 49.24 | 5.147 | 6.203 |
| Factor A (nitrogen) | 3 | 7.485* | 35.161* | 141.376* | 474.618* | 308.699* |
| Factor B (boron) | 2 | 5.324$^{NS}$ | 20.101$^{NS}$ | 91.223$^{NS}$ | 101.21$^{NS}$ | 39.076$^{NS}$ |
| AB | 6 | 0.521* | 0.375* | 21.76* | 23.859* | 3.609* |
| Error | 22 | 0.199 | 0.871 | 28.23 | 1.462 | 5.533 |

*significant at 5% level of probability,
NS- Non significant

**Appendix IV: Analysis of variance of the data on number of leaf per plant of rapeseed as influenced by different level of nitrogen and boron**

| Sources of Variation | Degrees of freedom | Mean Square | | | | |
|---|---|---|---|---|---|---|
| | | No. of Leaf per plant | | | | |
| | | 20 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 0.084 | 0.295 | 8.551 | 10.57 | 5.238 |
| Factor A (nitrogen) | 3 | 2.102* | 5.308* | 58.203* | 41.13* | 57.142* |
| Factor B (boron) | 2 | 0.587$^{NS}$ | 0.737$^{NS}$ | 34.401$^{NS}$ | 34.493$^{NS}$ | 42.041$^{NS}$ |
| AB | 6 | 0.993* | 0.911* | 3.954* | 4.404* | 9.762* |
| Error | 22 | 0.325 | 0.107 | 4.584 | 3.248 | 2.956 |

*significant at 5% level of probability,
NS- Non significant

**Appendix V: Analysis of variance of the data on number of primary branch of mustard as influenced by different level of nitrogen and boron**

| Sources of Variation | Degrees of freedom | Mean Square | | | |
|---|---|---|---|---|---|
| | | No. of Primary Branch | | | |
| | | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 0.522 | 2.177 | 0.436 | 0.658 |
| Factor A (nitrogen) | 3 | 0.605* | 9.865* | 15.187* | 10.783* |
| Factor B (boron) | 2 | 0.014$^{NS}$ | 1.066$^{NS}$ | 0.77$^{NS}$ | 0.908$^{NS}$ |
| AB | 6 | 0.302* | 0.453* | 1.227* | 0.677* |
| Error | 22 | 0.136* | 0.499* | 0.492* | 0.511* |

*significant at 5% level of probability,
NS- Non significant

**Appendix VI: Analysis of variance of the data on length of inflorescence of rapeseed as influenced by different level of nitrogen and boron**

| Sources of Variation | Degrees of freedom | Mean Square | | | |
|---|---|---|---|---|---|
| | | Length of inflorescence | | | |
| | | 50 DAS | 60 DAS | 70 DAS | 80 DAS |
| Replication | 2 | 0.308 | 3.914 | 5.896 | 1.841 |
| Factor A (nitrogen) | 3 | 16.402* | 13.785* | 41.929* | 15.936* |
| Factor B (boron) | 2 | 19.468 $^{NS}$ | 17.234 $^{NS}$ | 40.809 $^{NS}$ | 15.834 $^{NS}$ |
| AB | 6 | 2.897* | 1.455* | 13.698* | 3.086* |
| Error | 22 | 6.692 | 5.017 | 88.718 | 4.218 |

*significant at 5% level of probability,
NS- Non significant

**Appendix VII: Analysis of variance of the data on yield contributing character of rapeseed as influenced by different level of nitrogen and boron**

| Sources of Variation | Degrees of freedom | Mean Square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. of siliqua/plant | Seed weight of 100 siliquae (g)) | Seed weight/plant (g) | 1000 seed weight (g) | Seed yield (t/ha ) | Harvest Index (%) | Oil content (%) | Germination (%) |
| Replication | 2 | 29.78 | 1.22 | 0.49 | 0.12 | 17.13 | 2.32 | 0.342 | 4.694 |
| Factor A (nitrogen ) | 3 | 24.19* | 10.86* | 8.36* | 2.53* | 1.26* | 68.90* | 0.421 * | 1.667 $^{NS}$ |
| Factor B (boron) | 2 | 20.81* | 7.03* | 8.08* | 1.28* | 1.14* | 16.88* | 0.756 * | 9.528 $^{NS}$ |
| AB | 6 | 5.26* | 2.397* | 0.46* | 0.22* | 0.18* | 5.036* | 0.518 * | 0.75 $^{NS}$ |
| Error | 22 | 4.56 | 1.982 | 0.79 | 0.38 | 0.48 | 17.401 | 0.126 | 3.391 |

*significant at 5% level of probability,
NS- Non significant