EFFECT OF HIGHER DOSES OF UREA FERTILIZER OVER RECOMMENDED DOSE ON MUSTARD

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CERTIFICATE

This is to certify that the thesis entitled, ***"Effect of Higher Doses of Urea Fertilizer Over Recommended Dose on Mustard"*** *submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of* ***Master of Science (MS) in Agricultural Botany****, embodies the result of a piece of bona-fide research work conducted by* ***MD. SHIJAN ISLAM, Registration no. 19-10071*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this study has been dully acknowledgement by him.

Date:
Dhaka, Bangladesh

Dr. Nasima Akhter
Professor
Supervisor

DEDICATED

TO MY

BELOVED PARENTS

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ABSTRACT

The experiment was conducted at the research field of the Department of Agricultural Botany, Sher-e Bangla Agricultural University, Dhaka during the period from November 2019 to February 2020 to observe the effect of high doses urea on three different cultivars of mustard (BARI sarisha 11, BARI sarisha 16 and BARI sarisha 17). Three different levels of urea fertilizer was used such as T1 (250 kg/ha), T2 (312.50 kg/ha) and (375 kg/ha). The experiment was laid out under two factors Randomized Complete Block Design (RCBD) with 3 replications. Under T1, the tallest plant height at harvest was 131.86 cm (BARI recommended dose). Lowest plant height was observed 100.59 cm under treatment T3. Overdoes of urea may cause plant height to decrease. The highest number of leaves was recorded 38.43 under T3. So, we can see that plant became bushier when an excess amount of urea was applied. Seed per siliqua was also affected by different quantities of urea. Under the recommended dose, the highest number of seed per siliqua (21.44) was recorded. Higher urea doses (T3) most likely had a negative impact on seed output. In the case of seed dry weight and pod length, there was no significant association. As a result, the total influence on yield components was negligible. The physiological indicators were significantly affected by varying levels of urea administration. Significant differences were seen between the SPAD reading and the Leaf porometer reading. T3 obtained the highest SPAD measurement (49.88) and T1 recorded the highest Leaf porometer reading (336.95). Results indicate that Overdose of urea had detrimental effect on yield of mustard plant though vegetative growth was higher in case of higher dose. Number of seed per siliqua was found highest (21.44) under treatment T1 (250kg/ha).

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ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Per squares meter
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
^oC	=	Degree Celsius
%	=	Percentage

CHAPTER I

INTRODUCTION

Bangladesh is predominantly an agrarian country. Due to its very fertile land and favorable weather, varieties of crops grow abundantly in this country. The agriculture sector contributes about 14.23 percent to the country`s Gross Domestic Product (GDP) and employs around 40.60 percent of the total labor force (BBS, 2019). Although about seven oilseed crops are grown in the country rapeseed and mustard (Local and HYV) alone occupies about 667242 acres of the total 1098279 acres of the oilseed cultivated land and 311740 metric ton among the total 954182 metric tons which are about 60% of the oilseed production in Bangladesh (BBS, 2019). Mustard is the principal edible oil in Bangladesh.

Mustard belongs to the family Brassicaceae (Cruciferae), which is one of the most important oil crops of the world after soybean and groundnut (FAO, 2012). The three mustard species that produce edible oil are *Brassica napus, Brassica campestris, and Brassica juncea*, which are the world's third most important source of edible vegetable oil after palm and soybean. (Zhang and Zhou, 2006 and Adnan *et al.*, 2013). *B. napus and B. campestris* are considered "rapeseed," whilst *B. juncea* is considered mustard. Mustard and rapeseed are both members of the Cruciferae family and the genus Brassica. Though rapeseed and mustard are both members of the same family and genus, they have distinct plant characteristics. It is used as a condiment, salad, green manure, and fodder crop and leaf and stem as vegetables in the various mustard growing countries of the world Mustard oil are mainly used for the edible purpose and apart finds industrial applications. Oil cake is used as manure and animal feed. It is a mainly self-pollinating crop, although an average of 7.0 to 30% out-crossing does occur under natural field conditions (Rakow and Woods, 1987).

Mustard cultivars with high yields respond well to fertilizers, notably nitrogen. It is also more receptive to nitrogenous fertilizer when it is irrigated rather than when it is rain-fed (Chowdhury *et al.*, 2006). It promotes the passage of assimilates to flowers, forming siliqua, and, eventually, seed production. Brassica's growth, development, and production have been impeded for decades due to a variety of problems, including imbalanced plant mineral nutrients in soils and biotic stresses (Chowdhury *et al.*, 2006). Plant reaction to additional nitrogen (N) has proven to be a valuable agronomic technique since time immemorial, and the application of nitrogen (N) has been a crucial element for plant growth since time immemorial. The delivery of nitrogen in oilseed and rapeseed is critical for excellent yields. Rapeseed is a significant user of nitrogen, yet accessible nitrogen is a scarce resource in many parts of the world (Kessel, 2000 and Rossato *et al.*, 2001). Therefore, energy and high costs of fertilizer nutrients necessitate economizing their use. Due to many loss processes in the field, the recovery of applied nitrogen is limited. Due to poor soil water conditions, split fertilizer application, which is recommended to increase nitrogen use efficiency, is frequently impractical. As a result, when the regime is favorable, the entire amount of nitrogen is required to be applied in a single broadcast application. However, a single broadcast application causes nitrogen loss. It has been proven that the deep application of USG improves nitrogen utilization efficiency. The placement technology is most suited to situations where ammonia volatilization, rather than leaching or denitrification, is the primary nitrogen loss process. With moderate to heavy textured soil, low permeability and percolation rate, and high cataion exchange capacity, the deep distribution of USG has a better advantage than surface split application (Mohanty et al., 2007).

Oilseed production and area are gradually declining due to (i) low yield potential of oilseed varieties (ii) high disease and pest infestation compared to other crops (iii) yield instability due to microclimatic fluctuation (iv) expansion of irrigation facilities and availability of more profitable crops in place of in cropping patterns. Although most oilseed crops react well to intensive treatment, they are unable to compete with other high-value crops. Typically, farmers do not designate their good land for oil crops and do not adopt current cultural norms. As a result, their returns are poor (Alam, 2007).

So far, there has been very little research done at the end-user level to investigate farmer engagement and efficiency variations regarding the effect of urea fertilizer over recommended dose on mustard. Taking these factors into account, the current research was carried out with the following goals in mind-

i. To evaluate the higher urea fertilizer doses on mustard considering, morphology, yield attributes and yield.

ii. To study the varietal performance with different higher urea fertilizer doses.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this Chapter is to review the past studies conducted by different researchers related to the present study. As far as possible, the researcher tried to review the available literature from different countries related to mustard and rapeseed. These are Bangladesh's most frequent and important oil crops, as well as those of many other countries throughout the world. In comparison to developed countries, Bangladesh's average mustard productivity is poor. Researchers have focused their attention on numerous areas of the crop's cultivation. Many studies have been conducted in various parts of the globe. Bangladesh's work thus far has been insufficient and conclusive. Nonetheless, in this chapter, some of the most essential and useful papers and research discoveries on nitrogen fertilizer effect on mustard and rapeseed are reviewed.

2.1 Effect of Urea on Morphology of Mustard

Ali *et al.* (1990) reported that mustard plant height was dramatically boosted when varying quantities of nitrogen were used. Gaffer and Razzaque (1983), as well as Asaduzzaman and Shamsuddin (1986), worked on mustard and published reports on plant height.

Saikia *et al.* (2002) reported that throughout the rabi season of 1998-99, the reaction of Indian mustard cv. Pusa giant grown in New Delhi, India. They discovered that those cultivars respond better to USG than prilled urea or neem coated urea. Majnoun-Hosseini *et al.* (2006) suggested that plant height would be raised if planting space was reduced and nitrogen fertilizer was used.

According to Mondal and Gaffer (1983), nitrogen has the most dramatic effect on plant growth and output of all-important elements. Nitrogen has a substantial effect on plant height, branches plant^{-1}, pods plant^{-1}, and other growth variables, as well as mustard production, according to the literature. Nitrogen promotes plant vegetative development and postpones maturity. Excessive use of this element, according to Sheppard and Bates (1980) and Singh et al. (1972), might result in excessive vegetative growth, impairing fruit output.

Rana and Pachauri (2001) tested the sensitivity of zero erucic acid genotypes of Oleiferous Brassica to plant population and planting geometry, finding that both plant densities and nitrogen levels had a significant effect on mustard plant height at maturity.

Tripathi (2003) investigated the effects of N levels (80, 120, 160, and 200 kg ha-1) on the growth, yield, and quality of Indian mustard cv. Varuna in Uttar Pradesh, India, in 1994-95 and 1995-96. At sowing, first irrigation, and 60 days after sowing, nitrogen was administered in three equal splits. The number of branches per plant grew up to 200 kg N ha-1, and all yield parameters except number of branches 6 increased with increasing N levels up to 160 kg N ha-1. Because seed yield was also highest at this N rate, net returns were highest (Rs. 19901 ha-1) at 160 kg N ha^{-1}. The benefit-to-cost ratio jumped to 160 kg N ha-1.

According to Chauhan *et al.* (1993) row spacing had no effect on the plant height of toria,. They looked at three different row spacing options: 20, 30, and 40 cm. The maximum plant height was found at 20 cm row spacing, which was comparable to the plant heights found at 30 cm row spacing and 40 cm row spacing. It was discovered that as row spacing was increased, plant height dropped. Meitei *et al.* (2001) conducted a two-year experiment to examine the influence of spacing on the yield and yield components of B. juncea var. Rugosa cultivars (Hanggam Amubi, Hanggam Angoubi, and Hanggam Anganbi). They discovered that Hanggam Angoubi produced the tallest plants (52.25 and 48.29 cm) and that a population density of 23000 plants ha-1 produced the tallest plants (55.00 and 48.38 cm). Rana and Pachauri (2001) found in a field experiment in New Delhi that plant height was higher in 340000 plants ha-1 population (166cm) than in 149000 plants ha-1.

Ali et al. (1996) reported that low density resulted in an increased number of branches per plant. Gupta (1988) used the mean population density of (330000 plants ha-1, 400000 plants ha-1, 200000 plants ha-1, 250000 plants ha-1, 166000 plants ha-1, 266000 plants ha-1) to conduct a field experiment to determine the effects of spacing on rapeseed, and he discovered that wider spacing increased the number of branches plant-1.

Gurjar and Chauhan (1997) conducted a field experiment in Gwalior and found that with 30 15 cm row spacing (6.72 and 21.57 branches plant-1), as opposed to 45 15 cm

(5.80 and 16.76 branches plant-1), primary and secondary branches plant-1 were significantly greater. According to Leach *et al.* (1999) plants grown at high density produced fewer pod-bearing branches per plant but produced more branches.

Rana and Pachauri (2001) also discovered that with 340000 plants ha-1 density, the number of secondary branches plant-1 was higher (7.6 branches plant-1). Sharif *et al.* (1990) discovered that the number of branches on plant-1 was much higher than the number of branches on plant-2. Plant density of 30 plants per m2 is superior to that of 60 and 90 plants per m^2.

According to Tomar and Namedo (1989) when the population density of Brassica campestris var. Toria was kept at 22.2 plants m-2, the number of primary and secondary branches increased when the seed rate of rapeseed was kept at 5 kg ha-1. Chauhan *et al.* (1995) and Cheema *et al.* (2001) found that with increasing quantities of nitrogen fertilizer application, the number of siliqua-1 and TSW seeds grew significantly.

According to Khan *et al.* (2003), cycocel at 400 ppm + 60 kg N ha-1 and ethrel at 200 ppm + 80 kg N ha-1 increased leaf photosynthetic rate, water usage efficiency, leaf area, and leaf dry mass 80 days after sowing. 120 days after seeding, the largest stem, pod, and plant dry mass were recorded. Pod quantity and seed output rose as the plant matured. Allen and Morgan are a couple (1972) Nitrogen boosts yield by altering many growth parameters and promoting more vigorous growth, as seen by increased plant height, number of flowering branches, total plant weight, leaf area index, and quantity and weight of siliquae and seeds per plant. According to Holmes and Ainsley (1977), nitrogen fertilizer requirements vary greatly depending on soil type, climate, management practices, nitrogen application timing, cultivars, and other factors.

According to Wright *et al.* (1988), a higher rate of nitrogen delivery at sowing results in faster leaf area development, longer leaf life, better leaf area duration after blooming, and enhanced overall crop absorption, all of which contribute to higher seed output.

Rana and Pachauri (2001) in a field experiment in New Delhi found that with 330000 plants ha-1 (24.8 percent) compared to 148000 plants ha-1, the harvest index was greater (20.4 percent). Mustard cultivars reacted to N treatment up to 80 kg ha-1, according to Babu and Sarkar (2002). With an increase in fertilizer N, mustard cultivars' dry matter production, N content, and N uptake all increased significantly. The uptake of soil N by mustard cultivars increased dramatically as N levels increased, demonstrating the 'priming' or 'added nitrogen interaction effect' of applied nitrogen.

2.2 Effect of Urea on Yield Attributes and Yield of Mustard

Allen and Morgan (1972) found that the Nitrogen rate increases from 0-211 kg N ha-1. LAI, plant dry matter, pod dry matter, number of pods plant-1, number of seeds pod-1, and seed yields all increased. Mir *et al.* (2000) found that fertilizer dose had a substantial impact on mustard production and yield contributing features in an experiment. At a rate of 78.46 kg N ha-1, the maximum 5 height of the plant, number of primary branches, the weight of seed plant-1, dry matter weight of plants, and seed yield were reached.

According to Momoh and Zhou (2001), when plant density increased, the number of functional branches and pods per branch dropped. Sharif *et al.* (1990) kept population densities of 30, 60, and 90 plants per square meter for rapeseed production, claiming a positive response from all yield contributors. Singh (2002) discovered that applying N and P to mustard enhanced the length of the siliqua, the number of siliqua plants-1, the number of seeds per siliqua, seed yield, and 1000-seed weight. The 60, 90, and 120 kg N ha-1 and 30, 45, and 60 kg P ha-1 treatments, on the other hand, showed a considerable increase in yield and yield components. Application of 45 kilogram P ha-1 (11.43 and 13.85 q/ha in 1999 and 2000, respectively) and 120 kg N ha-1 (12.98 and 13.83 q/ha in 1999 and 2000, respectively) resulted in the highest seed yield. With the addition of N and P, the oil content increased slightly, but not significantly.

Qayyum *et al.* (1998) and Cheema et al. (2001) found that applying up to 120 and 135 kg N ha-1 increased the number of seeds per siliqua, respectively. Reddy and Sinha (1989) demonstrated that increasing nitrogen consumption improved seed yield linearly; as compared to no nitrogen consumption, quantities of 40 and 80 Kg N ha-1 raised seed production to 49.5 percent and 96.5 percent, respectively.

Sharawat *et al.* (2002) found that when the rate of N and S increased, so did the yield and oil content. The highest number of siliqua plant-1 (397.25), weight of siliqua plant-1 (33.32 g), 10 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 were obtained when N was applied at 120 kg ha-1 (38.39 percent).

According to Bani Saeedi (2001), nitrogen increased seed output per hectare by reducing floral abscission and thereby affecting thousand-seed weight (TSW), increasing the number of siliqua per unit area and decreasing the number of seeds siliqua-1. According to Gangasaran *et al.* (1981), regression analysis found that siliqua weight had a considerable impact on seed yield, although siliqua length and diameter had only a minor impact. Al-Barzinjy *et al.* (1999) studied the impacts of various plant densities in rapeseed, ranging from 20 to 130 plants m-2. They discovered that as plant density grew, pods per plant, seed weights, and dry mass per plant dropped.

Gurjar and Chauhan (1997) in a field experiment in Gwalior discovered that the number of siliquae plant-1 measured was larger with 30 cm 15 cm row spacing (444) than with 45 cm 15 cm row spacing (440).

Rana and Pachauri (2001) found that the number of siliquae plant-1 (272) was larger, with 340000 plants ha-1 compared to 148000 plants ha-1 population density. Sharma (1992) conducted a field experiment at the College of Agriculture in Gwalior (Madhya Pradesh) and found that a 30 cm row spacing produced more siliquae plant-1 (233.4) than a 45 cm row spacing (228.4). Mishra and Rana (1992) also found that a 60 cm row spacing resulted in a higher quantity of siliquae-1 seeds than a 30 cm or 45 cm row spacing.

Rana and Pachauri (2001) found that the number of seeds siliquae-1 observed was considerably higher under 220000 plants ha-1 compared to 500000 plants ha-1.

Sharma (1992) conducted a field experiment at the College of Agriculture in Gwalior (Madhya Pradesh) and found that row spacing of 45 cm produced more seeds siliqua-1 than row spacing of 30 cm. According to Chauhan *et al.* (1993), row spacing and 1000-seed weight have a favorable relationship. They discovered that row spacing (20, 30 and 40 cm) had a substantial effect on the weight of 1000 Toria seeds. The row spacing with the maximum weight of 1000 seeds was 40 cm, whereas the row spacing with the lowest weight was 20 cm. Sharma (1992) discovered that increasing row spacing resulted in a considerable rise in 1000-seed weight in many mustard cultivars. He experimented with four different row spacings: 30.0, 33.5, 37.5, and 45.0 cm. The maximum seed weight was discovered at 45 cm, which was much greater than the other row spacings. 33.5 cm row spacing yielded the lowest seed weight.

Singh and Singh (1987) observed no significant effect of row spacing on mustard 1000-seed weight in an experiment with three-row spacing (30, 45, and 60cm). However, the weight increased when row 13 spacing was increased, with 60 cm row spacing yielding the maximum seed weight and 30 cm row spacing yielding the lowest weight of 1000 seeds. Tomar and Namedo (1989) studied Brassica campestris var. Toria and found that when the population density was kept at 22.2 plants m-2, the weight of 1000 seeds increased. On pooled seed yield, the interaction effect of variety and plant populations was shown to be substantial. Abdin *et al.* (2003) studied the effects of S and N on the yield and quality of Indian mustard cv. Pusa Jai Kisan (V1) and rape cv. Pusa Gold in Rajasthan, Haryana, and Uttar Pradesh, India (V2). T1 [(S0:N (50 + 50)]; T2 [S40:N (50 + 50)] for V1 and [S40:N(50 + 25 + 25) for V2]; and T3 [(S20 + 20):N(50 + 50) for V1 and S(20 + 10 + 10):N(50 + 25 + 25) for V2] were the treatments. The seed and oil yields of both crops increased significantly after a split treatment of S and N (T3). Under T3, the average seed yield from the various trial 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 for V1 was 1.71 t/ha, and for V2 it was 1.42 t/ha. With the split application of S and N, the oil and protein content of V1 and V2 seeds increased as well. These findings suggest that splitting the application of 40 kg S/ha and 100 kg N ha-1 throughout the proper phenological periods of crop growth and development can improve mustard production and quality.

Both Chauhan *et al.* (1995) and Cheema *et al.* (2001) reported that increasing nitrogen fertilizer treatment enhanced the number of seeds per siliqua and the thousand-seed weight (TSW). Behera *et al.* (2002) conducted a field experiment to investigate the effect of plant population and sulfur levels on mustard (B. juncea) yield, and discovered significant interaction effects of variety and plant population on pooled seed yield, with the maximum seed yield recorded at the intermediate population level of 14.8 plants m-2. According to Greath and Schweiger (1991) the nitrogen intake and transport of mustard cultivars can differ. They divided cultivars into three groups: type I-the higher the nitrogen application, the higher the yield; type II-the higher the nitrogen application, the higher the yield; type III-the higher the nitrogen application, the higher the yield; type IV-the higher the nitrogen application, the higher the yield; type V-the higher the nitrogen application, the higher the yield; type VI-the higher the nitrogen application, the higher the yield; type V-the higher the nitrogen application, the higher the yield;

type VI-the higher the The amount of nitrogen needed varies by location. More cultivation of 15 legume crops the previous year will not meet the nitrogen need for normal rape growth and productivity.

Rahman (1977) and Gupta *et al.* (1961) stated that in Bangladesh, a 135 kg N ha-1 application resulted in the highest seed yield under irrigated conditions. Applying 134 kg N ha-1 in fallow land rather than non-fallow land resulted in a highly cost-effective response for crop yield. Nitrogen application of up to 50 kg N ha-1 enhances dry matter, nitrogen content, and nitrogen and phosphorus uptake. Excessive nitrogen use in mustard can result in lodging, delayed maturity, lower oil content, and higher crude protein levels. Patel *et al.* (2004) investigated the effects of an irrigation schedule, spacing (30 and 40 cm), and N rates (50, 75, and 100 kg ha-1) on the growth, yield, and quality of Indian mustard cv. GM-2 in a field experiment in Gujarat, India, during the rabi season of 1999-2000. Three irrigations + 100 kg N ha-1 + 45 cm spacing resulted in a considerable improvement in yield when used in combination treatments. Enhanced N levels resulted in increased growth, yield characteristics, and seed yield, whereas increased rates resulted in lower oil content. N at 100 kg ha-1 also yielded the highest benefit-to-cost ratio.

According to Prasad *et al.* (2003), N at 30 kg ha-1 + P at 20 kg ha-1 + Zn at 5 kg ha 1 and 60 kg ha-1 + P at 30 kg ha-1 + S at 20 kg ha-1 produced the maximum growth, yield, and productivity, as well as a favorable cost-benefit ratio. Roy *et al.* (1981) achieved the maximum seed production (1957 kg ha-1) of mustard. Seed output declined after this point with the application of 240 kg N ha-1. The most cost-effective nitrogen application rate was 164 kg N ha-1. At 90 kg N ha-1, the effect of N was found to be considerable in another experiment. Rahman *et al.*, (1982) stated that the response on the seed yield contributing features was highest at 120 kg N ha-1, but not substantially better than at 90 kg N ha-1. Ali *et al.* (1977) reported that not applying nitrogen resulted in low seed weight. The yields were much lower than those of other higher rates. Siadat *et al.* (2010) found that nitrogen fertilizers increased seed yields significantly under a variety of circumstances. According to Singh and Rathi (1985), increases in nitrogen greatly boosted crop output; they observed the best yield with 160 kg N ha-1.

According to Singh *et al.* (2004), nitrogen application had no effect on mustard oil content, but enhanced oil output and chlorophyll content by up to 90 kg N ha-1 over the control. The seed output of mustard was increased when nitrogen was added to the mix. The treatment of 90 kg N ha-1 increased the nitrogen and sulphur content of seed and straw, as well as total N and S uptake. Increased nitrogen and sulphur content improved total nitrogen and sulphur intake. Sinsinwar *et al.* (2004) conducted a field experiment n Bharatpur, Rajasthan, India to determine the best cropping sequence and N fertilizer application rate (0, 30, 60, and 90 kg ha-1) of Indian mustard cv. RH-30 under brackish water conditions during the 1999/2000 and 2000/01 rabi seasons. In both years, the cropping sequences had no effect on plant height, number of primary and secondary branches per plant, number of siliquae plant-1, 1000-seed weight, or seed production. Up to 60 kg ha-1 of N fertilizer, the seed yield of Indian mustard improved dramatically, but after that, the increase was modest. With 30 and 60 kg N ha-1, respectively, seed yield increased by 33.3 and 83.8 percent on average compared to the control. Kjellstrom (1993) found that increasing the usage of nitrogen manure produced the highest biological yield.

According to Meena *et al.* (2002), mustard seed and stover yields were considerably greater when 60 kg N ha-1 was applied compared to control and 30 kg N ha-1, and statistically comparable to 90 kg N ha-1. According to Sharif *et al.* (1990), the lowest population density of 30 plants m-2 produces the maximum crop production when compared to other treatments (60 and 90 plants m-2). Rana and Pachauri (2001) conducted a field experiment in New Delhi and found that 333000 plants ha-1 produced a higher seed output (1670 kg ha-1) than 148000 plants ha-1 (1280 kg ha-1).

According to Singh *et al.* (2004), nitrogen application had no effect on mustard oil content, but boosted oil output and chlorophyll content by up to 90 kg N/ha over the control. The seed output of mustard was increased when nitrogen was added to the mix. 18 The treatment of 90 kg N/ha increased the nitrogen and sulphur content of seed and straw, as well as total N and S uptake. Increased nitrogen and sulphur content improved total nitrogen and sulphur intake. In comparison to 60 kg N/ha, Singh *et al.* (2003) found that 120 kg N/ha generated 4.51 times more branches, 48.03 times more siliqua number, 2.09 g siliqua weight, 2.05 g higher seed weight per plant, and 2.55 q/ha greater seed output. N levels more than 120 kg/ha had no discernible effect on yield and yield characteristics. The basis of N application had no discernible effect on the plants' performance. In a study done in Poland, Islam (2016) looked at the effects of pre-sowing applications of NPK (161 kg/ha)+S (30 kg/ha) or Mg (5 kg/ha) and top dressings of N (0, 30, 25+5 and 60 kg/ha) on yield, yield components, and morphological aspects of white and Indian mustard seeds. The height, diameter of the stem base, and branching of Indian and white mustard stems were all increased by N top treatment (30, 25+5, and 60 kg/ha). Both crops, on the other hand, showed signs of lodging. Weather had no effect on the effects of NPKS and NPKMg on the yield potential of white mustard. Among the white mustard top dressing treatments, N applied at 30 kg/ha at the start of the flowering season produced the greatest results. When this rate was split into 25 kilogram N/ha solid fertilizer and 5 kg N/ha solution, the results were similar to the total rate of 30 kg N/ha solid fertilizer. N proved to be less productive at 60 kg/ha. The seed production was enhanced by applying N as a solid fertilizer at a rate of up to 60 kg/ha. Nitrogen should be administered in two parts, the first with phosphorus and potassium and the second after three weeks. Rapeseed and mustard require a lot of nitrogen to produce a lot of seed. For every tonne of seed produced, a spring rapeseed crop collects 50-60 kg of nitrogen (Geisler and Kullman, 1991; Grant and Bailey, 1993). The nitrogen equivalent for winter rapeseed is around 70 kg. One tonne of harvested seed includes 35 kg nitrogen, with 42 percent oil and 38 percent protein in the meal. As a result, rapeseed requires a lot of nitrogen to produce large yields (150-210 kg nitrogen for 3 tonnes ha-1).

CHAPTER III

METHODOLOGY

Methodology refers to the methods and procedures in the research work. In any scientific research, methodology plays an important role and requires very careful consideration. More appropriate the methodology more accurate the research. The basic materials for conducting any research are unbiased information and facts.

The methodology should be appropriate so that the researcher will be able to collect necessary data and analyze them in a proper way, which will help him to reach the correct decision. The building of research methodology requires a piece of vast knowledge, experience, and skill. Considering this, the researchers went through previous studies, obtained from supervisors and experts regarding all aspects of this piece of the study.

The experiment was conducted at the Research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, from November 2019 to February 2020 to examine the effect of urea fertilizer on the morphology and yield of mustard BARI sarisha-11, BARI sarisha-16 and BARI sarisah-17.

A sequential description of the methodologies followed in conducting this research work has been presented in this chapter.

3.1 Experimental site and soil

The experimental site was located at N 23°77' latitude and E 90°33' longitude with an elevation of 1.0 meters from sea level (Figure 1). The soil of the experimental site belongs to the Tejgaon series under the Agro-ecological zone, Madhupur Tract (AEZ 28), which falls into Deep Red Brown Terrace Soils. The soil of the experimental plots were clay loam, the land was medium-high with a medium fertility level (Appendix I). The characteristics of the experimental field are shown in Table 1.

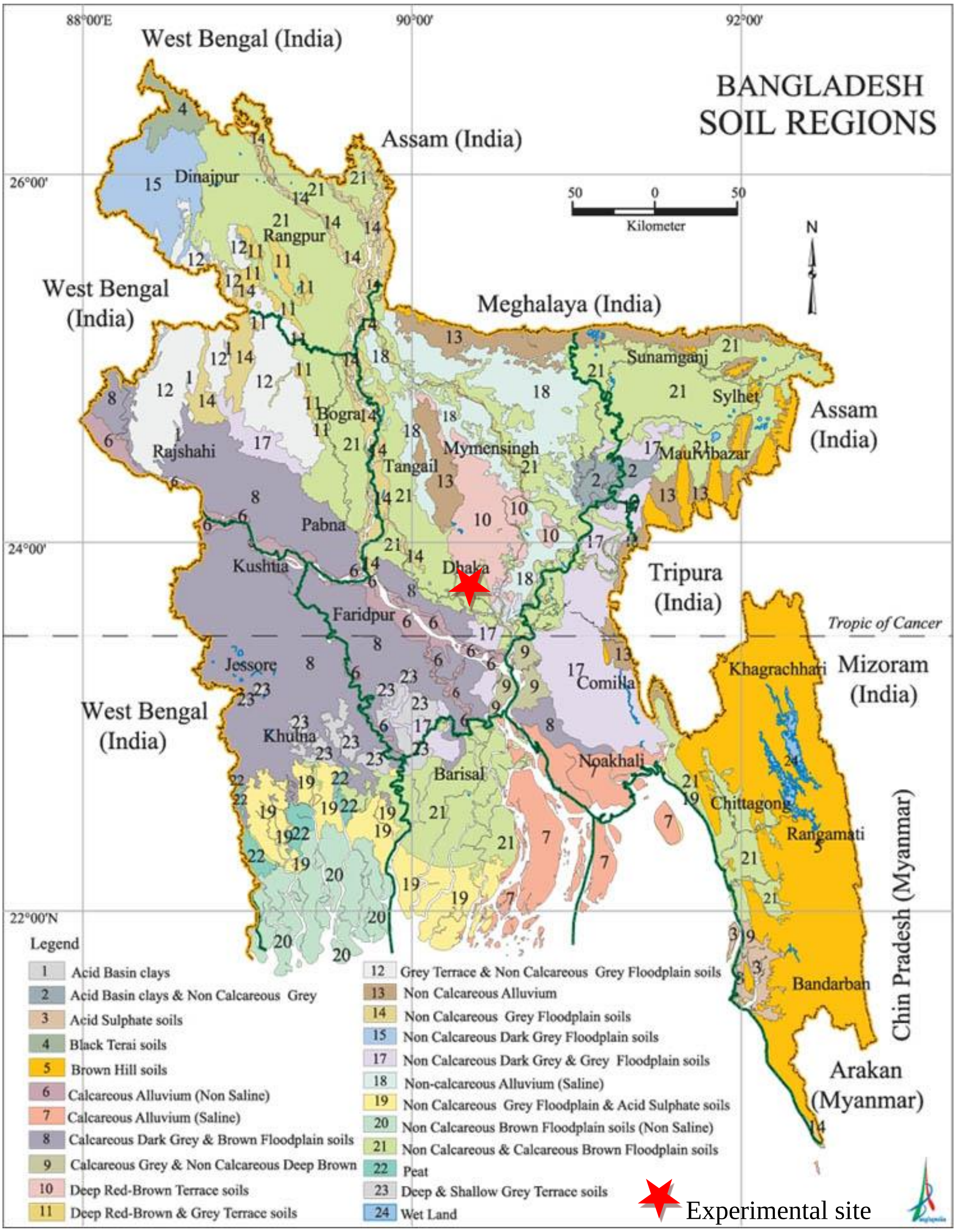


Figure 1. Map showing the experimental site under study

Table 1. Morphological characteristics of experimental field

Morphological Features	Characteristics
Location	Sher-e Bangla Agril. University Farm, Dhaka
AEZ No. and name	AEZ-28, Modhupur Tract
General soil type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of Inundation	Above flood level
Drainage condition	Well drained
Land type	High land

3.2 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix II.

3.3 Plant Materials

Seeds of BARI sarisha-11, BARI sarisha-16 and BARI sarisha-17 were used as plant material were used for the present study to see the comparison between old and newly released varieties. .

3.4 Experimental details

3.4.1 Treatments of the experiment

Factor A: Urea Doses (3)

T1= Recommended doses of urea (250 kg/ha) according to BARI

T2= 25% more urea than recommended doses of urea (312.5 kg/ha)

T3= 50% more urea than recommended doses of urea (375 kg/ha)

Factor B: Mustard Varieties

V1= BARI sarisha-11

V2= BARI sarisha-16

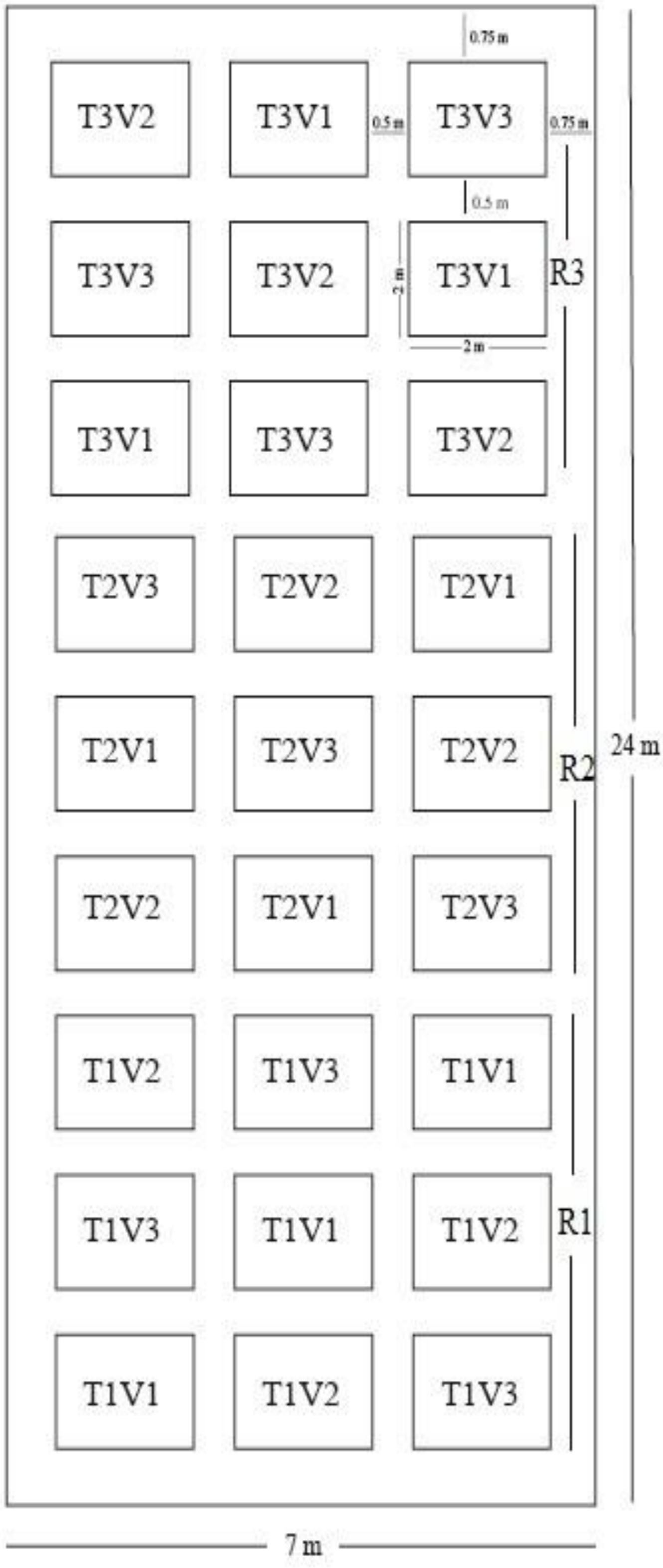
V3= BARI sarisha-17

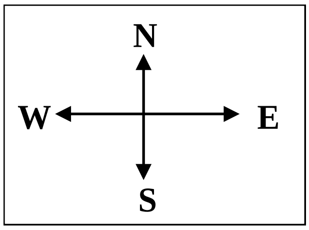
Treatment combinations: Nine (9) treatment combinations in three (3) blocks

1. T1V1 2. T1V2 3. T1V3 4. T2V1 5. T2V2 6. T2V3 7. T3V1 8. T3V2 9. T3V3

3.4.2 Experimental design and layout

With three replications, the experiment was set up in a factorial Randomized Complete Block Design (RCBD) with three replications. The experiment was set up in such a way that various levels of urea could be distributed. The 9 treatment combinations were randomly assigned to 3 plots. Each unit plot was 2 m x 2 m in size. Blocks and plots were separated by 0.75 m and 0.5 m, respectively.





Factor A: Nitrogen application– Three levels

T1= Recommended doses of urea fertilizer (250 kg/ha)

T2= 25% more N than recommended doses of urea fertilizer (312.5 kg/ha)

T3= 50% more N than recommended doses of urea fertilizer (375 kg/ha)

Factor B: Different mustard varieties

V_1 = BARI sarisha-11

V_2 = BARI sarisha-16

V_3 = BARI sarisha-17

R1= Replication 1

R2= Replication 2

R3= Replication 3

Figure 2. Layout of the experimental plot

3.4.3 Collection of seeds

BARI sarisha-11, BARI sarisha-16 and BARI sarisha-17 a high-yielding variety of mustard developed by Bangladesh Agricultural Research Institute (BARI), Gazipur was used as a test crop. Seeds were collected from BARI, Joydebpur, Gazipur.

3.5 Preparation of the main field

The plot selected for the experiment was ploweded with a power tiller, and was exposed to the sun for a few days, after that the land was harrowed, plowed and cross-plowed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for sowing seeds. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water and remained opened for few days.

3.6 Fertilizer application

Triple superphosphate (TSP =180 kg/ha), Muriate of potash (MOP=85 kg/ha), Gypsum (150 kg/ha), Zinc sulphate (5 kg/ha) and Borax (10 kg/ha) were used as source of phosphorus, potassium, sulphur, zinc and boron respectively. The total amount of TSP, MOP, gypsum, zinc, and borax were applied as basal doses during the final land preparation of all plots. Half of the urea was applied during final land preparation and the rest half was applied before flowering (40 DAS) for urea treatment. Urea was applied as recommended, 25% more and 50% more at each time as assigned.

3.7 Plant protection

The crop was infested with aphids (*Lipaphis erysimi*) at the time of siliqua filling. The insects were controlled successfully by spraying Malathion 50 EC @ 2ml L-1 water. The insecticide was sprayed twice, the first on 30 November 2019 and the last on 15 January, 2020. The crop was kept under constant observation from sowing to harvesting.

3.8 Weeding and thinning

Thinning was done two times at 30 and 50 days after emergence and hand weeding was done three times at 30, 50 and 65 days after sowing.

3.9 Irrigation

Irrigation was done as per requirements. Four irrigations at the time before sowing; at 15 DAE, 30 DAE, 60 DAE were given under the present study.

3.10 Intercultural operation

After the establishment of seedlings, various intercultural operations were accomplished for better growth and development of the mustard.

3.11 Data collection and tagging

Five plants were selected randomly from each unit plot for recording data on crop parameters and the yield of grain and straw were taken plot-wise. The following parameters were recorded during the study:

3.11.1 Morphophysiological parameters

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Number of flowers plant^{-1}
4. Number of branches plant^{-1}
5. Dry weight of plant
6. SPAD reading
7. Leaf porometer reading

3.11.2 Yield contributing parameters

8. Number of siliquae plant^{-1}
9. Length of siliqua (cm)
10. Number of seeds siliqua^{-1}
11. Yield (gm)

3.11.3 Procedure of recording data

3.11.4 Plant height

The height of the plant was recorded in centimeters (cm) at the time of harvest. Data were recorded as the average of 5 plants of each plot. The height was measured from the ground level to the tip of the leaves and the average was recorded.

3.11.5 Number of leaves plant^{-1}

Number of leaves were calculated from randomly selected 5 sample plants and the mean data was recorded at 20, 45, 60 and 80 DAS.

3.11.6 Number of flowers plant^{-1}

Number of flowers were calculated from randomly selected 5 sample plants and the mean data was recorded at 20, 45 and 60 DAS.

3.11.7 Number of branches plant^{-1}

The total number of branches was counted from randomly selected 5 plants of each plot. The average branches number was calculated which is termed as number of branches plant-1.

3.11.8 Dry weight of plant

The number of total 5 plants from each unit plot was preserved and the mean number was expressed after sun drying of the plants.

3.11.9 SPAD reading

The number of total 5 plants from each unit plot was selected and the reading was taken by SPAD reading meter.

3.11.10 Leaf porometer reading

The number of total 5 plants from each unit plot was selected and the reading was taken by LP meter.

3.11.11Number of siliquae plant^{-1}

The number of total siliquae of 5 plants from each unit plot was noted and the mean number was expressed as per plant basis.

3.11.12 Length of siliqua

The length of 5 siliquae from each sample was collected randomly and the mean length was expressed as per siliqua basis (cm).

3.11.13 Number of seeds siliqua^{-1}

Number of total seeds of 5 randomly selected samples of siliquae from each plot was noted and the mean number was expressed as per siliqua basis.

3.11.14 Seed yield

Dry weight of seed (at 10% moisture level) from harvested area of each plot was taken and then converted to gm.

3.12 Harvest and threshing

The crop was harvested when more than 80% siliqua were ripped at 10 February. For collection of data the harvested crops were separated treatment wise. After separation siliqua were dried in sunlight, then shelled and the grains were cleaned properly.

3.13 Statistical Analysis

The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Tukey's HSD test using Statistix 10 software with the Least Significant Difference value was determined with 5% levels of significance and the means were tabulated. The mean comparison was carried out by the DMRT technique (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The effect of different levels of nitrogen on some growth, yield components and physiological parameters of three different mustard varieties was observed in this experiment. Results have been discussed below following sub-headings:

4.1 Effect of different urea fertilizer on morphological characters of mustard

4.1.1 Plant height at harvest (cm)

The highest plant height (131.86 cm) was observed under treatment T1 (250kg/ha) and the lowest (100.59 cm) plant height was recorded under treatment T3 (375 kg/ha) Significant difference (Figure 3) in plant height was found at harvest among three cultivars of the mustard plant. The highest plant height (150.62 cm) was observed (Figure 4) in BARI sarisha-16 (V2) and the lowest value (83.19 cm) was found in BARI sarisha-17 (V3). 102.6 cm height was seen in BARI sarisha-11 (V3). This variation might be due to their genetic traits.

The effect of interaction between cultivars and urea fertilizer on plant height was significant (Table 2). The tallest plant (179.97 cm) was found in BARI Sarisha-16 when treated with 250 kg/ha urea (T1V2) at harvest. The lowest (70.09 cm) in BARI Sarisha-17 when treated with 375kg/ha urea (T3V3).

Shamsuddin *et al.* (1987) and Mondal and Gaffer (1983), reported that different varieties of mustard differed significantly in plant height. Ali et al. (1990), Mir et al. (2000), Rana and Pachauri (2001) found a significant changes in plant height for different levels of fertilizers. Ali *et al.* (1990) reported that mustard plant height was dramatically boosted when varying quantities of nitrogen were used. Gaffer and Razzaque (1983), as well as Asaduzzaman and Shamsuddin (1986), worked on mustard and published similar reports on plant height. Shamsuddin *et al.* (1987) and Mondal and Gaffer (1983). They reported that different varieties of mustard differed significantly in plant heigh. Ali *et al.* (1990), Mir *et al.* (2000), Rana and Pachauri (2001) found significant change in plant height for different levels of fertilizer.

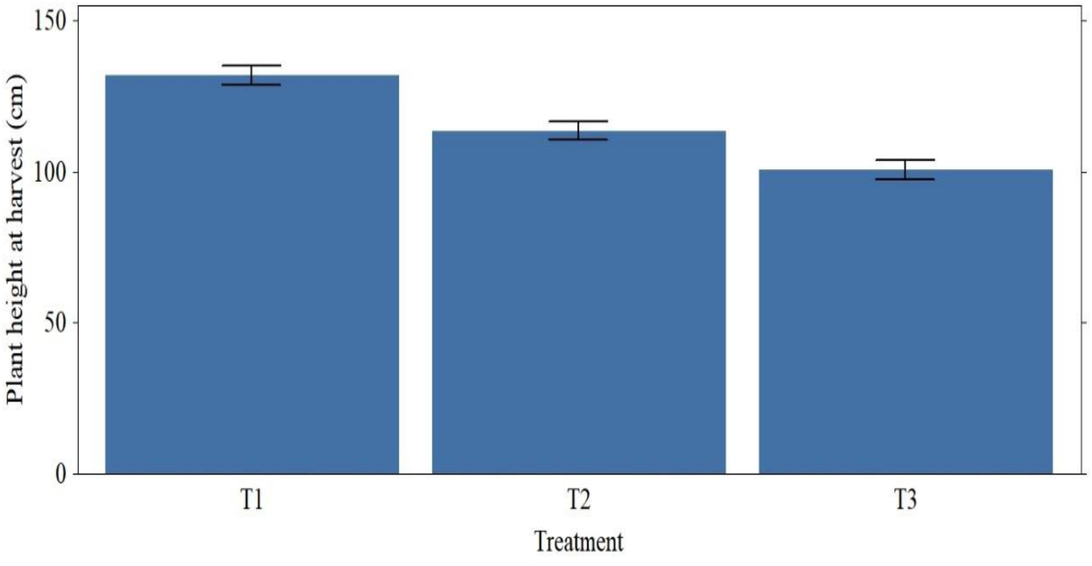


Figure 3: Plant height of mustard at the time of harvest regarding urea fertilizer application

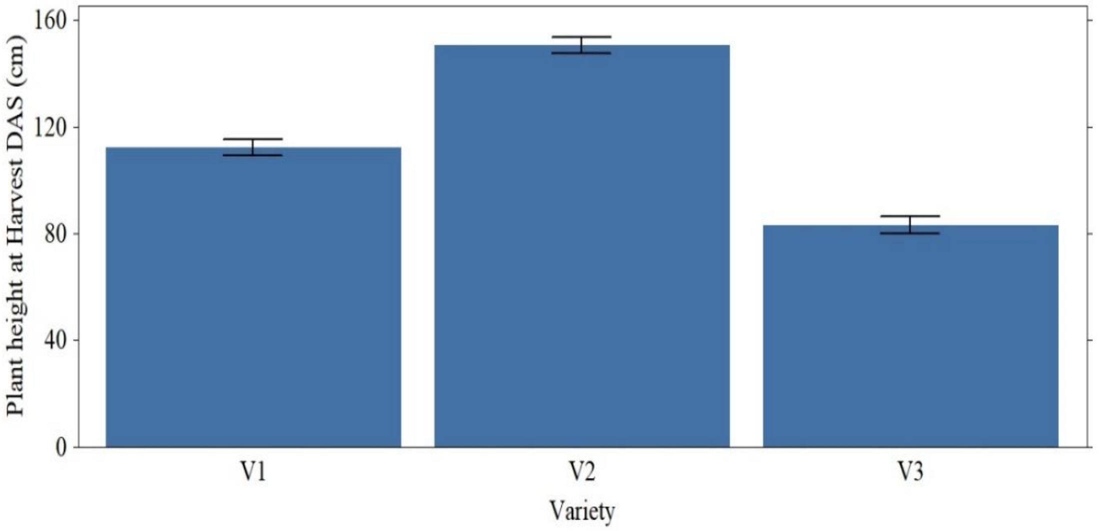


Figure 4: Plant height of mustard at time the of harvest regarding varieties

Table 2: Interaction of urea fertilizer and varieties on plant height of mustard at the time of harvest

Urea fertilizer and varieties		Plant height at harvest
T1	V1	122.14 c
	V2	179.97 a
	V3	93.47 de
T2	V1	99.44 d
	V2	155.00 b
	V3	86.00 e
T3	V1	114.78 c
	V2	116.89 c
	V3	70.09 f
LSD $_{0.05}$		11.645
Significance Level		**
CV%		3.47

4.1.2 Number of branches at the time of harvest

A remarkable difference was observed on number of branches per plant due to the effect of different levels of urea fertilizer application (Figure 5). It was observed that the urea fertilizer application: T1 (250kg/ha) and T2 (312.5 kg/ha) showed the highest number of branches per plant (7.00) and the lowest number of branches per plant (6.97) was observed in T3 (375 kg/ha).

Variation was found in the number of branches per plant within the plans of three different cultivars (Figure 6). The highest number of branches per plant was observed (7.10) in BARI sarisha-17 (V3) and the lowest value (6.90) was seen in BARI sarisha-16 (V2).

The combined effect of levels and variety also had non-significant effect on the number of branches per plant (Table 3). The highest observation (7.46) was seen in BARI sarisha-11 under treatment T1 (250 kg /ha). The lowest observation (6.63) was observed in BARI sarisha-16 under treatment T1 (250 kg/ha).

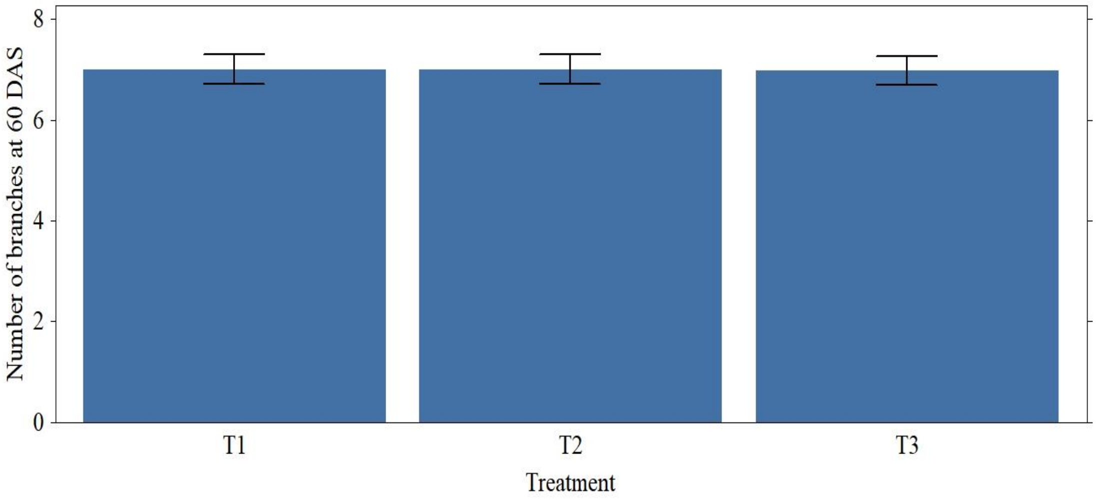


Figure 5: Number of branches at the time of harvest regarding urea fertilizer application

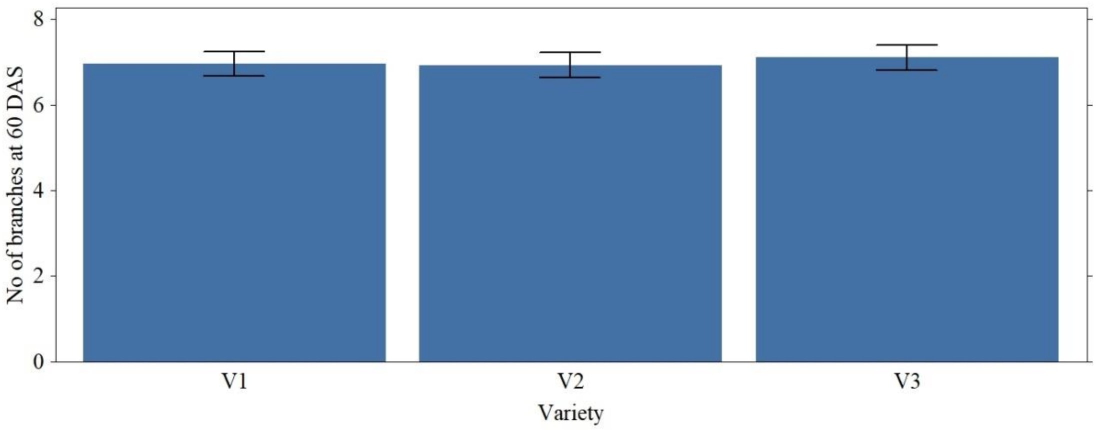


Figure 6: Number of branches at the time of harvest regarding varieties

Table 3: Interaction of urea fertilizer and varieties on the number of branches of the mustard plants at the time of harvest

Urea fertilizer and varieties		Number of branches at harvest
T1	V1	7.46
	V2	6.63
	V3	6.90
T2	V1	6.80
	V2	7.13
	V3	7.06
T3	V1	6.60
	V2	7.00
	V3	7.33
LSD $_{0.05}$		1.1025
Significance Level		NS
CV%		5.42

4.1.3 Number of leaves at the time of harvest

There were significant variations among treatments in respect of the number of leaves per plant (Figure 7). The Highest numbers of leaves per plant (38.43) were found in T3 (375 kg/ha) and the lowest value (11.63) was observed in T1 (250 kg/ha).

A significant difference was found among varieties in respect of number of leaves per plant (Figure 8). The highest value (37.91) was seen in BARI sarisha-11 (V1). Lowest value (29.57) was observed in BARI sarisha-17 (V3).

The interaction effect between varieties and N fertilizer were statistically significant (Table 4). The highest value (42.33) was observed in BARI sarisha-11 under treatment T3 (375 kg/ha). The minimum value (27.16) was seen BARI sarisha-17 under treatment T2 (250 kg/ha).

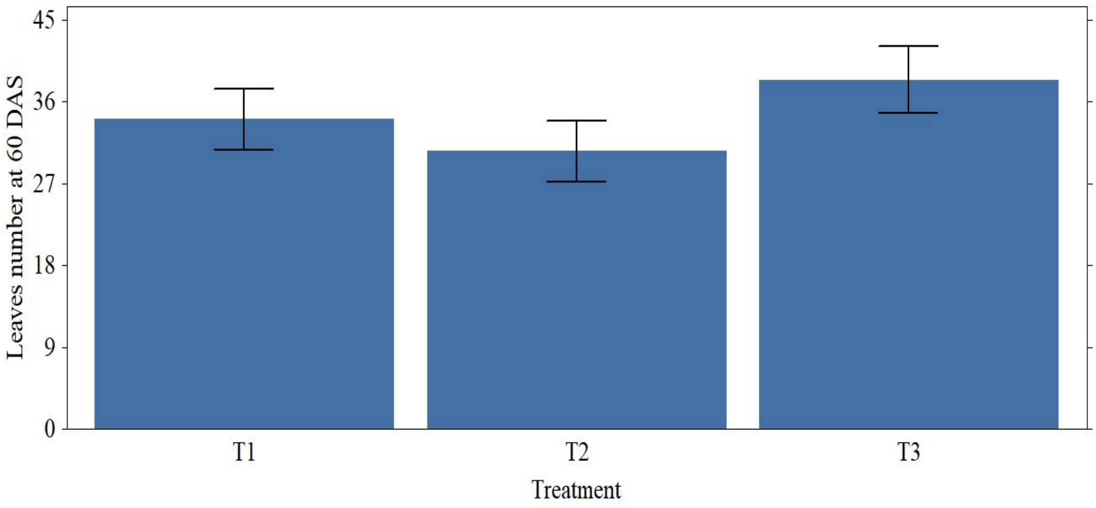


Figure 7: Number of leaves at the time of harvest regarding urea fertilizer application

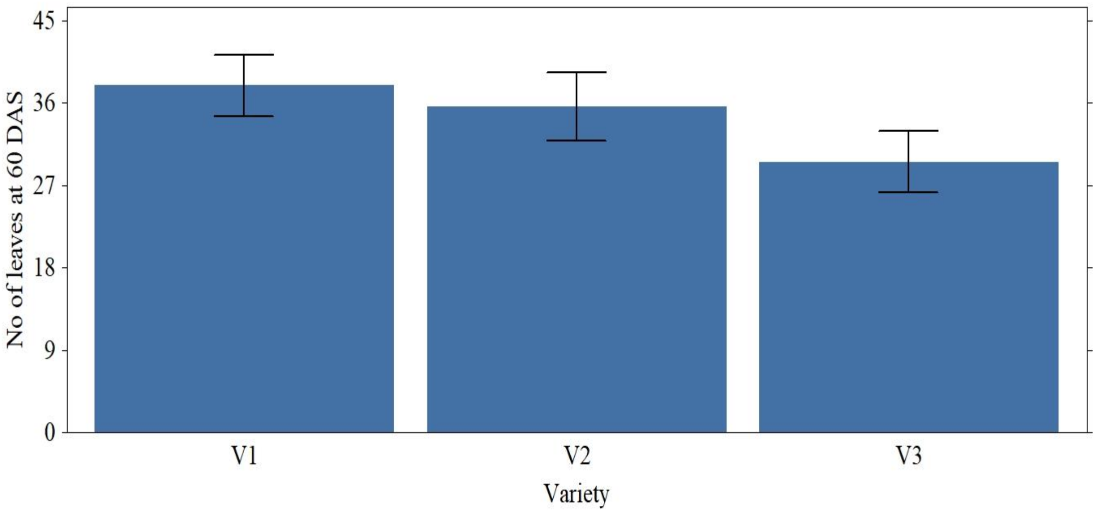


Figure 8: Number of leaves at the time of harvest regarding varieties

Table 4: Interaction of urea fertilizer and varieties on number of the leaves of the mustard plant at the time of harvest

Urea fertilizer and varieties		Number of leaves at harvest
T1	V1	35.86 a
	V2	39.20 ab
	V3	27.16 b
T2	V1	35.53 ab
	V2	27.93 b
	V3	28.20 b
T3	V1	42.33 a
	V2	39.60 ab
	V3	33.36 ab
LSD $_{0.05}$		12.688 to 14.362
Significance Level		*
CV%		12.60

4.1.4 Number of flowers at 60 DAS

There were significant variations among urea fertilizer application in respect of the number of flowers per plant at (Figure 9). The highest numbers of flowers per plant (15.22) were found in T3 (375 kg/ha) and the lowest number of flowers (10.51) was observed in T2 (312.50 kg/ha).

Statistically, non-significant variation was found among varieties in respect of the number of flowers per plant (Figure 10). The highest value (16.96) was seen in BARI sarisha-16 (V2). The lowest value (6.84) was observed in BARI sarisha-17 (V3). This is might be due to their genetic traits.

The combined effect between varieties and urea fertilizer was statistically significant (Table 5). The highest number of flowers (20.10) was seen in BARI sarisha-16 under treatment T1 (250 kg/ha and also in BARI sarisha-16 under treatment T3 (375 kg/ha). A minimum number of flowers (6.33) was observed in BARI sarisha-17 under T1 (250 kg/ha). Allen and Morgan (1972) found a significant relationship between the numbers of flowers and different levels of nitrogen doses.

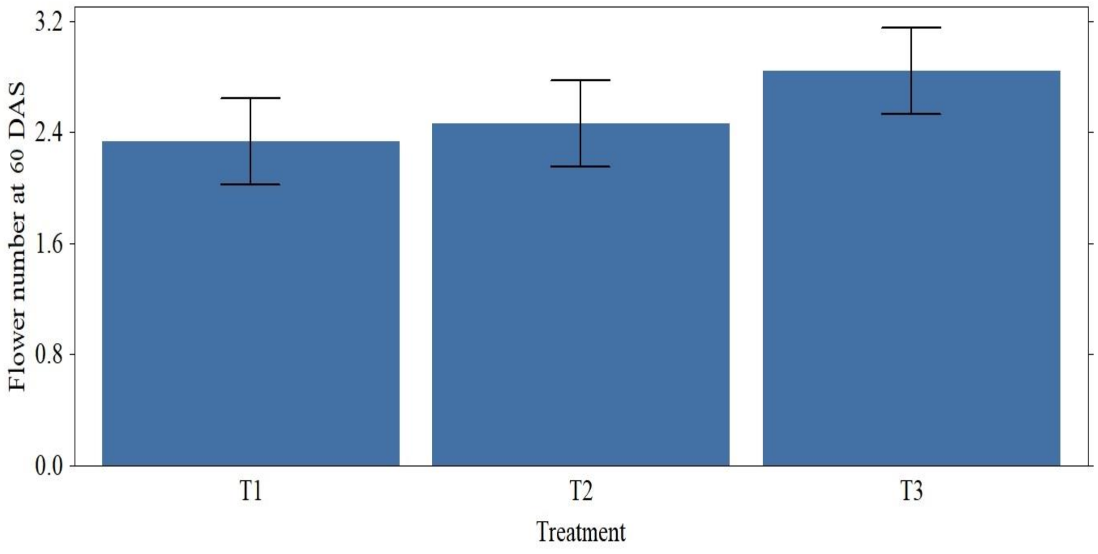


Figure 9: Number of flowers at 60 DAS regarding urea fertilizer application

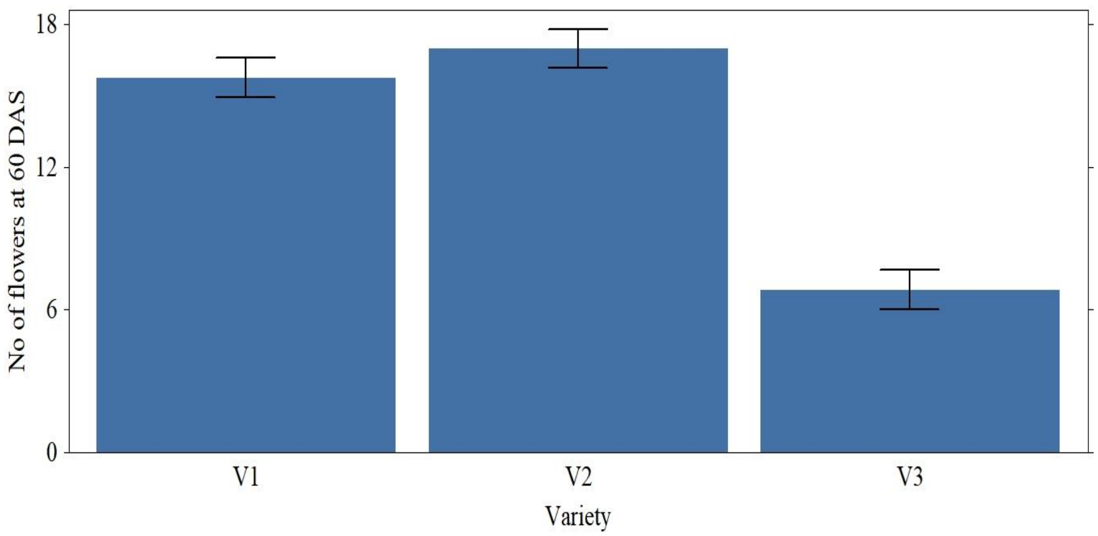


Figure 10: Number of flowers at 60 DAS regarding varieties

Table 5: Interaction of urea fertilizer and varieties on the number of the flowers of the mustard plant at 60 DAS

Urea fertilizer and varieties		Number of flowers at 60 DAS
T1	V1	15.06 bc
	V2	20.10 a
	V3	6.33 d
T2	V1	12.46 c
	V2	12.66 c
	V3	6.40 d
T3	V1	19.73 a
	V2	18.13 ab
	V3	7.80 d
$LSD_{0.05}$		3.0911
Significance Level		**
CV%		8.06

4.1.5 Numbers of siliqua at the time of harvest

There were significant variations among treatments in respect of the number of siliquae per plant during harvesting time (Figure 11). The Highest numbers of siliqua per plant (131.96) were found in T2 (312.50 kg/ha) and the lowest number of flowers (124.19) was observed in T1 (250 kg/ha).

There were statistically significant differences observed among the cultivars in the number of siliquae per plant (Figure 12). Where highest number (168.76) was found in BARI sarisha-16 (V2) and the minimum of siliqua (68.11) was observed in BARI sarisha-17.

Combination effect of urea fertilizer and variety has given a significant effect in respect of siliqua number per plant (Table 6). The maximumm (180.55) number of siliquae was seen in BARI sarisha-16 under T3 (375 kg/ha) and minimum number (59.11) was seen in BARI sarisha-17 under T1 (250 kg/ha). Sinsinwar et al. (2004), Rana and Pachauri (2001), Sharma (1992), Bhagwan et al. (1996). Found a significant increase in the number of siliquae with the increase of urea fertilizer.

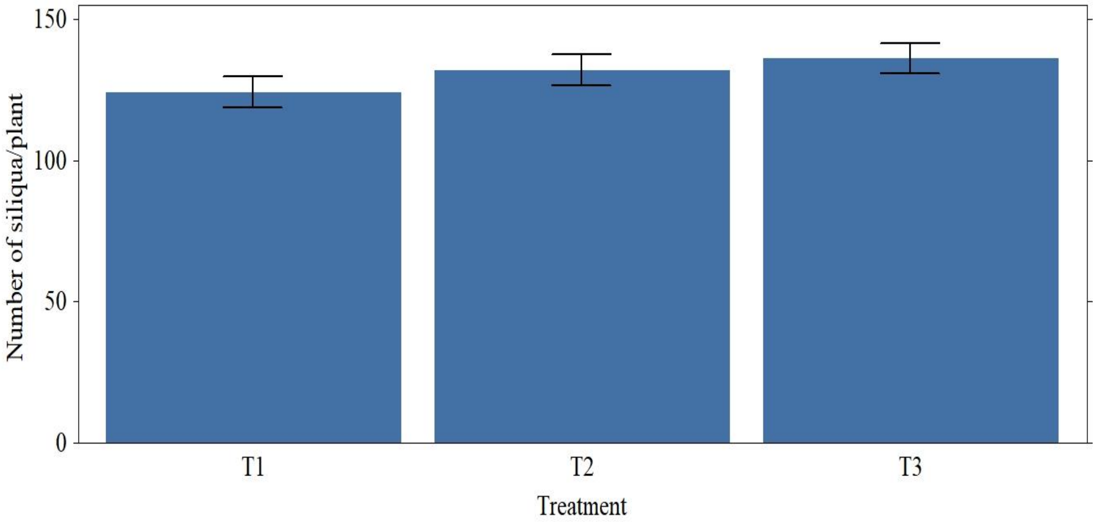


Figure 11: Number of siliquae/plant at the time of harvest regarding urea fertilizer application

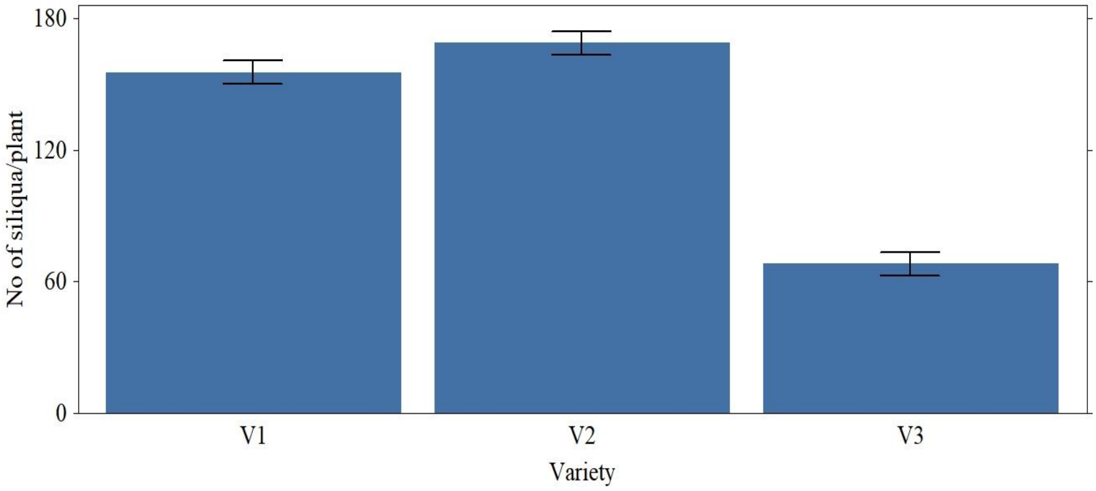


Figure 12: Number of siliquae/plant at the time of harvest regarding varieties

Table 6: Interaction of urea fertilizer and varieties on the number of the siliqua of the mustard plant at the time of harvest

Urea fertilizer and varieties		Number of siliquae/plant during harvest
T1	V1	143.83 c
	V2	169.62 ab
	V3	59.11 e
T2	V1	158.00 bc
	V2	156.11 bc
	V3	81.78 d
T3	V1	164.56 ab
	V2	180.55 a
	V3	63.44 de
$LSD_{0.05}$		20.641
Significance Level		**
CV%		5.43

4.1.6 Plant dry weight (gm)

Plant dry weight influenced by different levels of urea fertilizer doses was found non-significant (Figure 13). The highest plant dry weight (6.03 gm) was noted from both T1 (250 kg/ha) and T3 (375 kg/ha). The Lowest (5.88gm) value was seen in T2 (312.50 kg/ha).

Plant dry weight was seen to differ significantly among the three cultivars (Figure 14). This variation in plant dry weight might be attributed to their genetic characters. The Highest plant dry weight (6.67 gm) was gained by BARI sarisha-11 (V1) and the lowest (5.20 gm) was seen in BARI sarisha-16 (V2).

The combined effect of urea fertilizer and varieties created a significant variation in plant dry weight (Table 7). The highest weight (6.98 gm) was found in BARI sarisha-11 under T2 (312.50 kg/ha). The lowest weight (4.00 gm) gained by plants was weighted in BARI sarisha-16 T2 (312.50 kg/ha). Mir *et al.* (2000), Khan *et al.* (2003)

found a significant relationship between Plant dry matter and different levels of nitrogen doses.

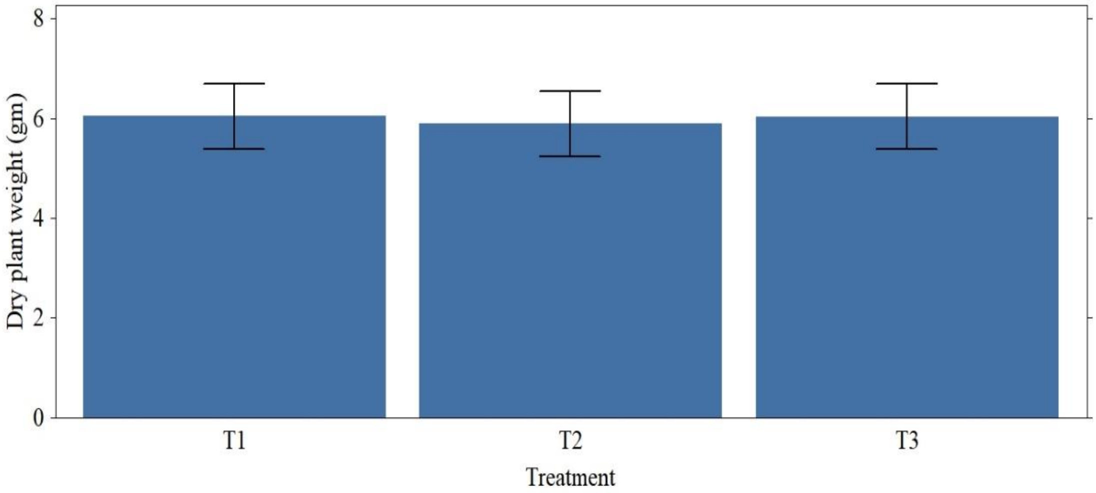


Figure 13: Plant dry weight at the time of harvest regarding urea fertilizer application

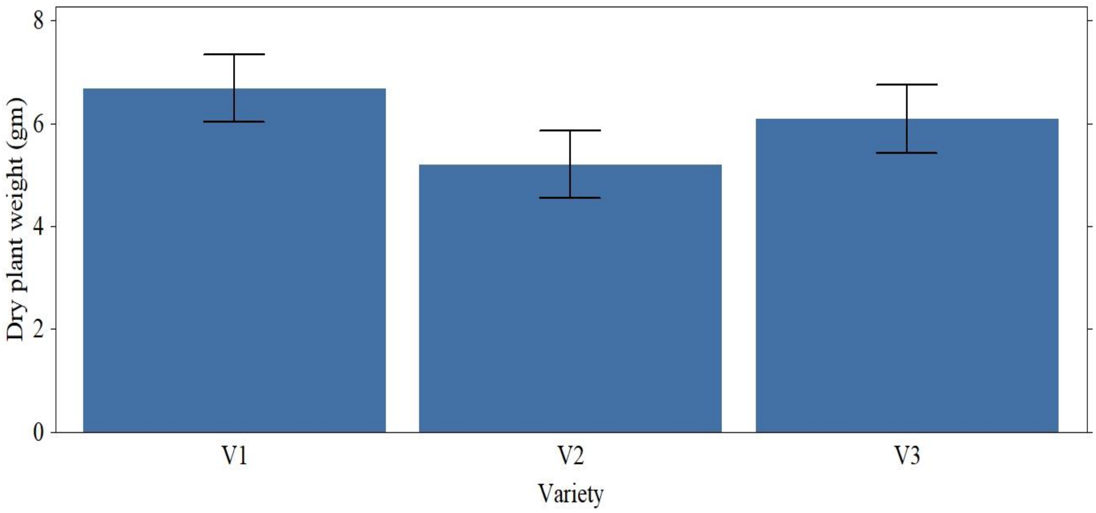


Figure 14: Plant dry weight at the time of harvest regarding varieties

Table 7: Interaction of urea fertilizer and varieties on the plant dry weight at the time of harvest

Urea fertilizer and varieties		Plant dry weight (gm) during harvest
T1	V1	6.32 ab
	V2	6.89 a
	V3	4.90 ab
T2	V1	6.98 a
	V2	4.00 b
	V3	6.67 a
T3	V1	6.73 a
	V2	4.70 ab
	V3	6.67 a
LSD $_{0.05}$		2.4972
Significance Level		**
CV%		14.35

4.1.7 SPAD reading

SPAD readings were significant in respect to different urea fertilizer levels (Figure 15). The Highest SPAD reading (49.88) was found in T3 (375 kg/ha) and lowest SPAD reading (43.75) was observed under T2 (312.50 kg/ha).

SPAD reading among different varieties was non-significa (Figure 16). The Highest SPAD reading (47.37) was found in BARI sarisha-11 (V1) and the lowest SPAD reading (45.83) was recorded in BARI sarisha-16 (V2).

The Combined effect of urea and varieties on SPAD reading was statistically non-significant (Table 8). The highest SPAD reading was recorded in BARI sarisha-16 under T3 (375 kg/ha) and the lowest SPAD reading (36.66) was recorded in BARI sarisha-16 under T2 (312.50 kg/ha).

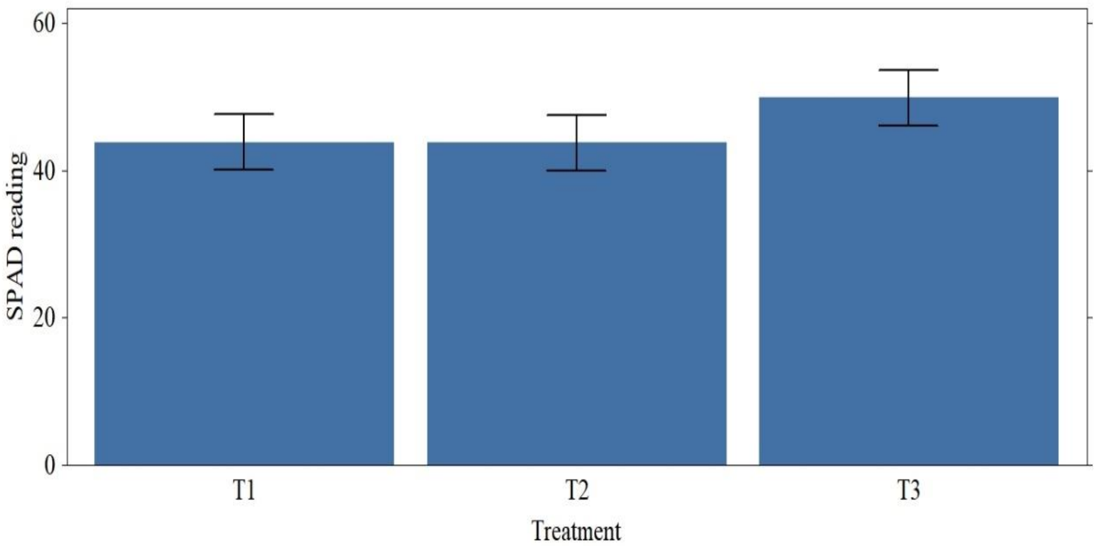


Figure 15: SPAD reading regarding urea fertilizer application

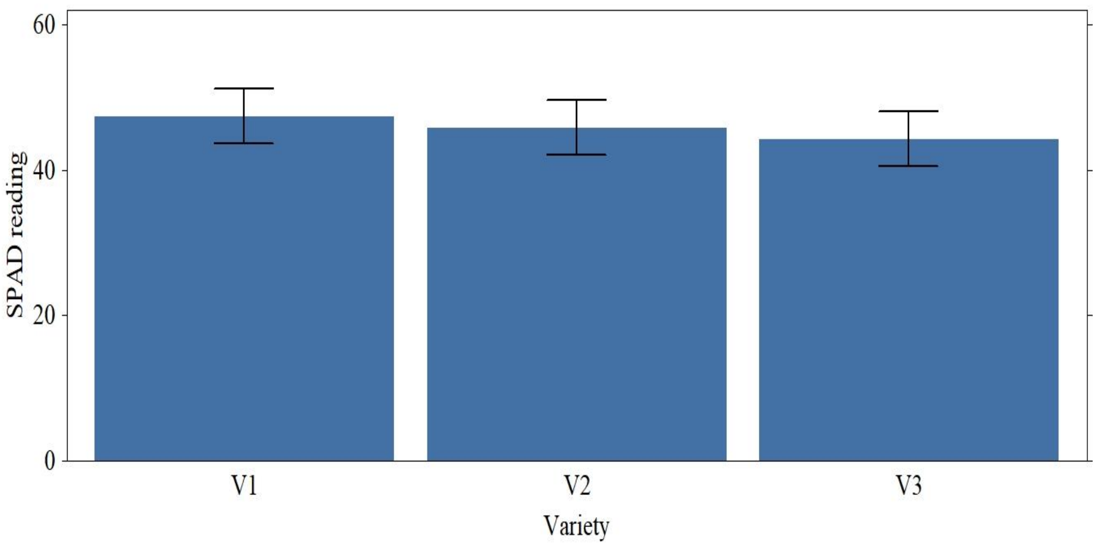


Figure 16: SPAD reading regarding varieties

Table 8: Interaction of urea fertilizer and varieties on the SPAD reading

Urea fertilizer and varieties		SPAD reading
T1	V1	46.50 ab
	V2	46.13 ab
	V3	38.80 b
T2	V1	47.93 ab
	V2	36.66 b
	V3	46.66 ab
T3	V1	47.70 ab
	V2	54.70 a
	V3	47.26 ab
LSD $_{0.05}$		14.250
Significance Level		**
CV%		10.70

4.1.8 Leaf conductance

Leaf porometer reading variation was significant under different treatments (Figure 17). The highest LPR value (336.95) was observed under T1 (250 kg/ha) and the lowest value (195.47) was observed under T3 (375 kg/ha).

LPR variation was significant among three different cultivars (Figure 18). The highest LPR value (330.97) was observed in BARI sarisha-11 (V1) and the lowest value (237.97) was seen in BARI sarisha-17 (V3).

The combined effect of different levels of nitrogen and varieties was significant (Table 9). The Highest LPR value (380.95 sc-1) was observed in BARI sarisha-11 under T1 (250 kg/ha). The lowest LPR value (161.47 sc-1) was found in BARI sarisha-17 under T3 (375 kg/ha).

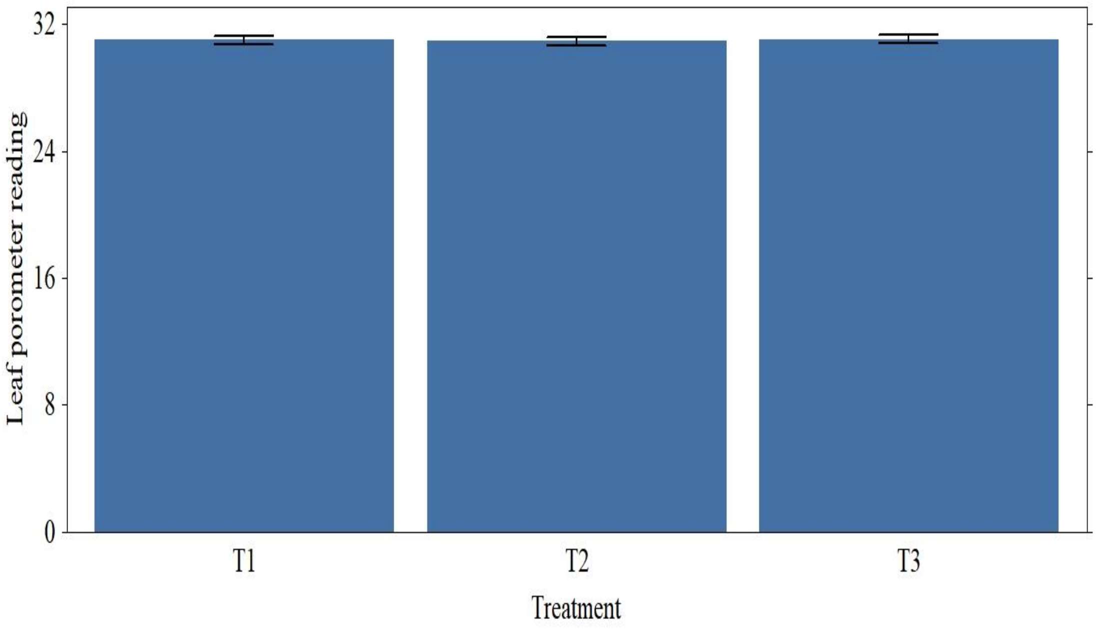


Figure 17: Leaf conductance regarding urea fertilizer application

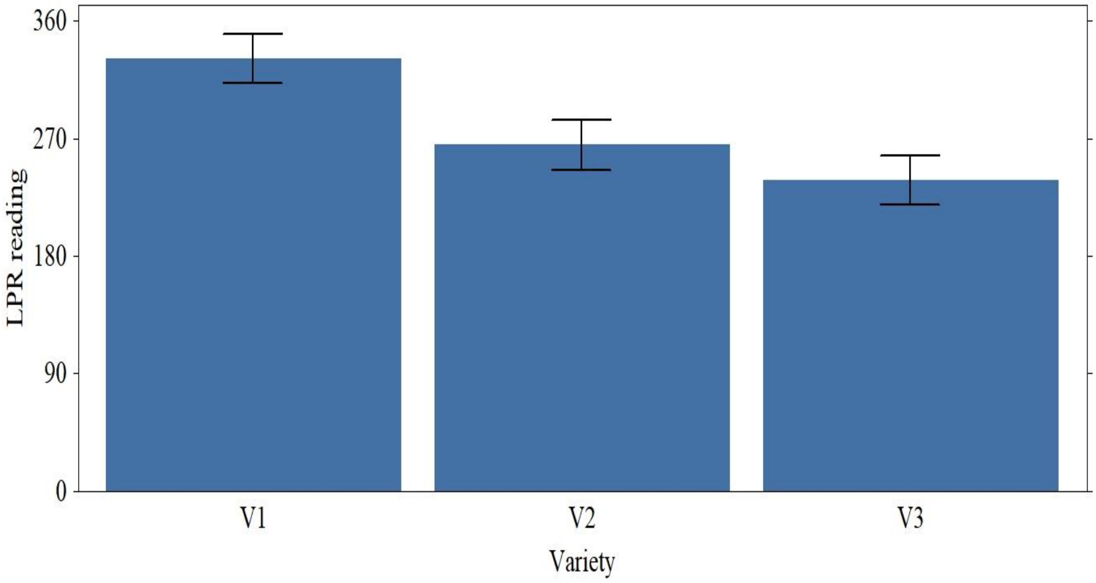


Figure 18: Leaf conductance regarding varieties

Table 9: Interaction of urea fertilizer and varieties on the leaf conductance

Urea fertilizer and varieties		LPR	Temperature
T1	V1	380.95 a	30.93
	V2	252.00 b	30.83
	V3	377.90 a	31.23
T2	V1	377.87 a	31.00
	V2	352.13 a	30.80
	V3	174.53 cd	31.00
T3	V1	234.10 bc	30.96
	V2	190.83 bcd	30.90
	V3	161.47 d	31.20
LSD $_{0.05}$		72.099	1.0212
Significance Level		**	NS
CV%		8.92	1.13

4.2 Effect of different urea fertilizer doses on yield attributes and yield of mustard

4.2.1 Dry weight of seeds (gm)

Seed dry weight influenced by different levels of urea application was found non-significant (Figure 19). The highest plant dry weight (12.55 gm) was noted from the treatment T3 (375 kg/ha). The lowest (11.35 gm) value was seen in treatment T1 (250 kg/ha).

Non-significantly variation among the three cultivars in respect of seed dry weight was noted (Figure 20). This variation in seed dry weight might be attributed to their genetic characters. The highest plant dry weight (13.42 gm) was gained by BARI sarisha-11 (V1) and the lowest (11.05gm) was seen in BARI sarisha-17 (V3).

The combined effect of nitrogen and variety created a significant variation in seed dry weight (Table 10). The highest weight (13.52gm) was found in BARI sarisha-11 under treatment T3 (375 kg/ha). The lowest weight (9.08gm) gained by plants was weighted in BARI sarisha-17 T2 (250 kg/ha). Mir *et al.* (2000), Al-Barzinjy *et al.* (1999) found a significant relationship in this case.

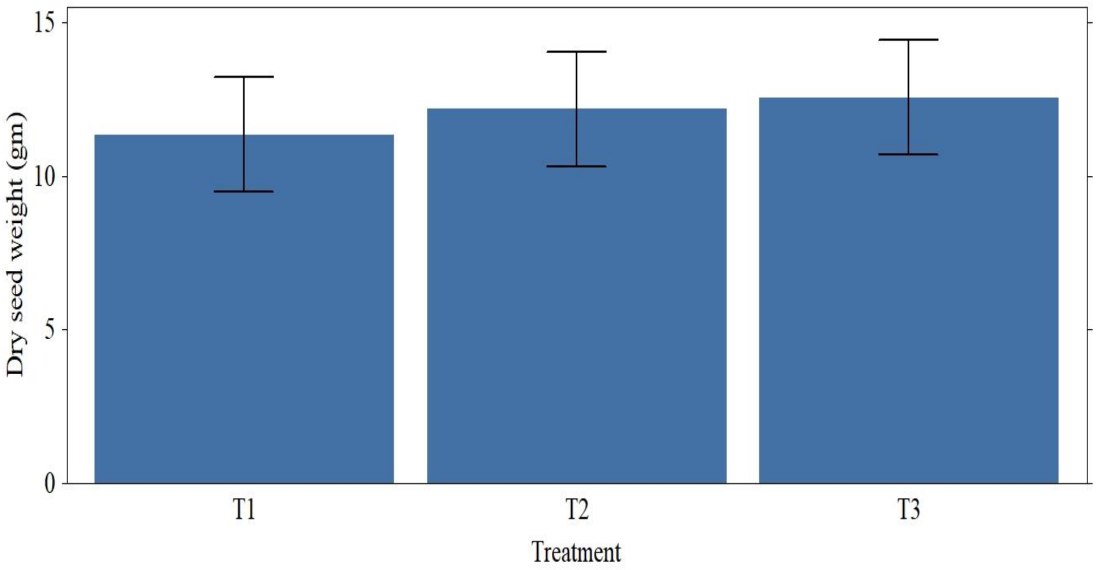


Figure 19: Dry weight of seeds regarding urea fertilizer application

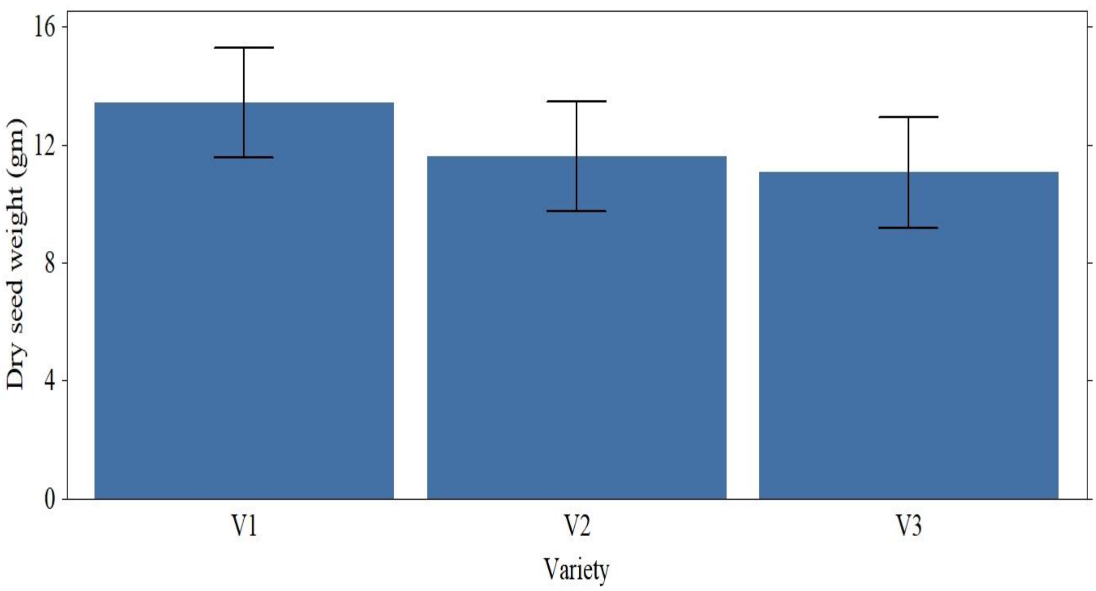


Figure 20: Dry weight of seeds regarding varieties

Table 10: Interaction of urea fertilizer and varieties on dry weight of seeds

Urea fertilizer and varieties		Dry weight of seeds (gm)
T1	V1	13.60
	V2	11.36
	V3	9.08
T2	V1	13.15
	V2	11.27
	V3	12.11
T3	V1	13.52
	V2	12.15
	V3	11.97
LSD $_{0.05}$		7.0730
Significance Level		NS
CV%		20.23

4.2.2 Number of seeds per siliqua

Number of seed per siliqua was found varied significantly in respect to different doses of urea (Figure 21). The highest number of seed per siliqua was recorded under treatment T1 (250 kg/ha). The lowest number of siliquae per plant (17.69) was recorded under treatment T2 (312.50 kg/ha).

Variation in seed per siliqua number was significant among the three cultivars (Figure 22). The highest number of seed per siliqua (25.37 gm) was found in BARI sarisha-11 and lowest quantity (15.50 gm) was weighted in BARI sarisha-17 (V3).

Interaction effect of urea and varieties over number of seeds per siliqua was significant (Table 11). The highest quantity (25.39gm) was found in BARI sarisha-17 under T3 (375 kg/ha). The lowest quantity (12.70 gm) was observed in BARI sarisha-11 under T3 (375 kg/ha).

The results confirmed the report of Deekshitula and Subbaiah (1997). Sarandon *et al.* (1993) stated that the application of N-fertilizer yielded a higher number of seeds per siliqua in mustard.

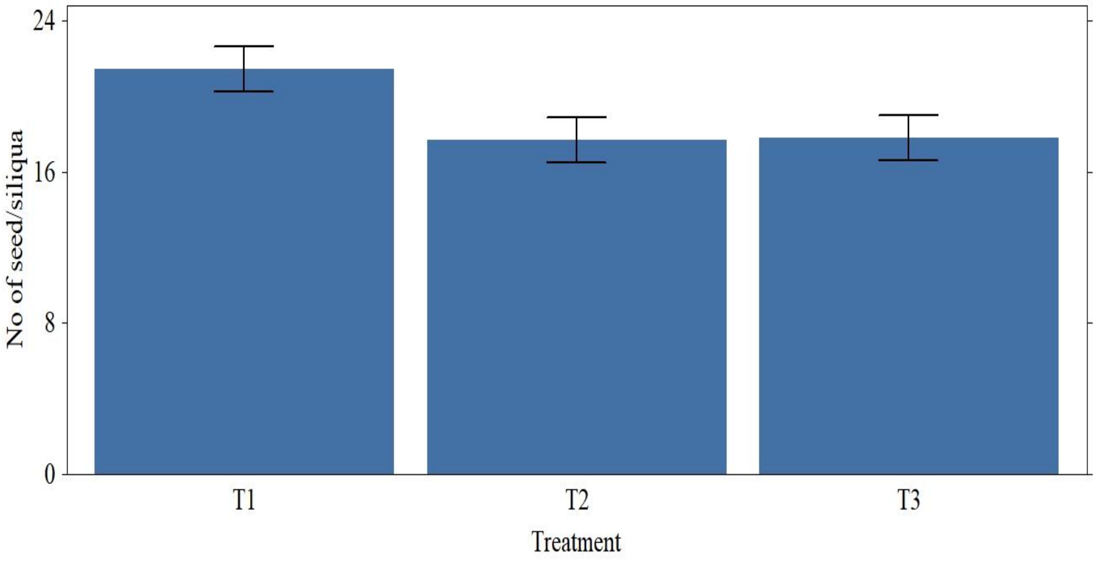


Figure 21: Number of seeds per siliqua regarding urea fertilizer application

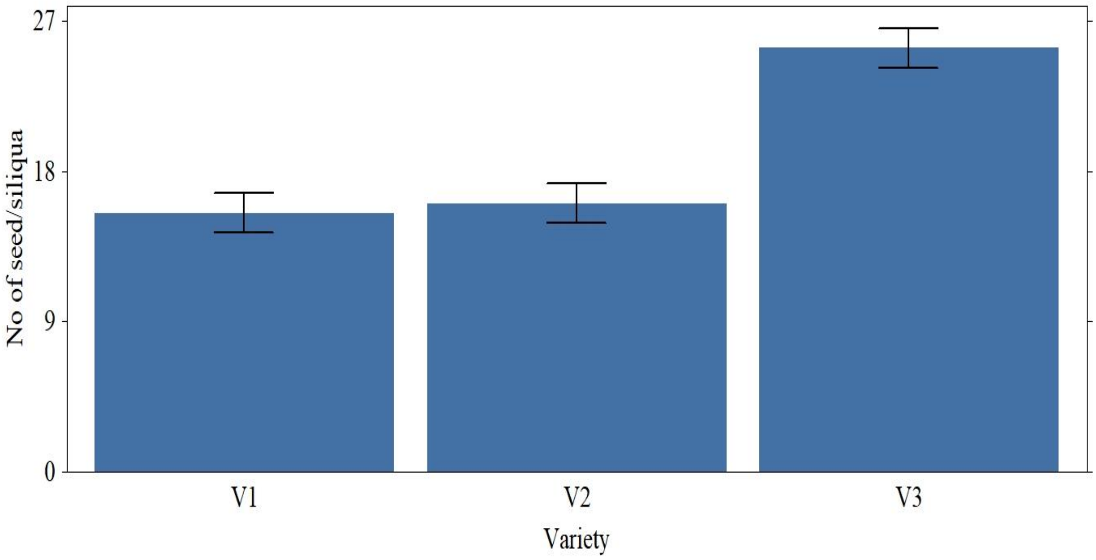


Figure 22: Number of seeds per siliqua regarding varieties

Table 11: Interaction of urea fertilizer and varieties on number of seed per siliqua

Urea fertilizer and varieties		Number of seed per siliqua
T1	V1	20.71 BC
	V2	18.10 CD
	V3	25.53 A
T2	V1	13.10 E
	V2	14.80 DE
	V3	25.17 AB
T3	V1	12.70 E
	V2	15.33 DE
	V3	25.39 A
$LSD_{0.05}$		4.4878
Significance Level		**
CV%		8.13

4.2.3 Pod's length after harvest (cm)

Five pod's length of mustard plant showed non-significant variations under different levels of urea doses (Figure 23). The highest pod length (4.76cm) was observed under T1 (250 kg/ha). The lowest pod length (4.42 cm) was found under T3 (375 kg/ha).

Cultivars showed statistically non-significant differences in respect to five pod's length (Figure 24). The highest length (4.78 cm) was found in BARI sarisha-11 (V1) and the lowest length (4.30) was found in BARI sarisha-17 (V3).

The combined effect of nitrogen and variety had a non-significant effect on five pod's length (Table 12). The highest length (5.34 cm) was observed in BARI sarisha-11 under T2 (312.50 kg/ha) and the lowest length (4.13 cm) was observed in BARI sarisha-17 under T2 (312.50 kg/ha).

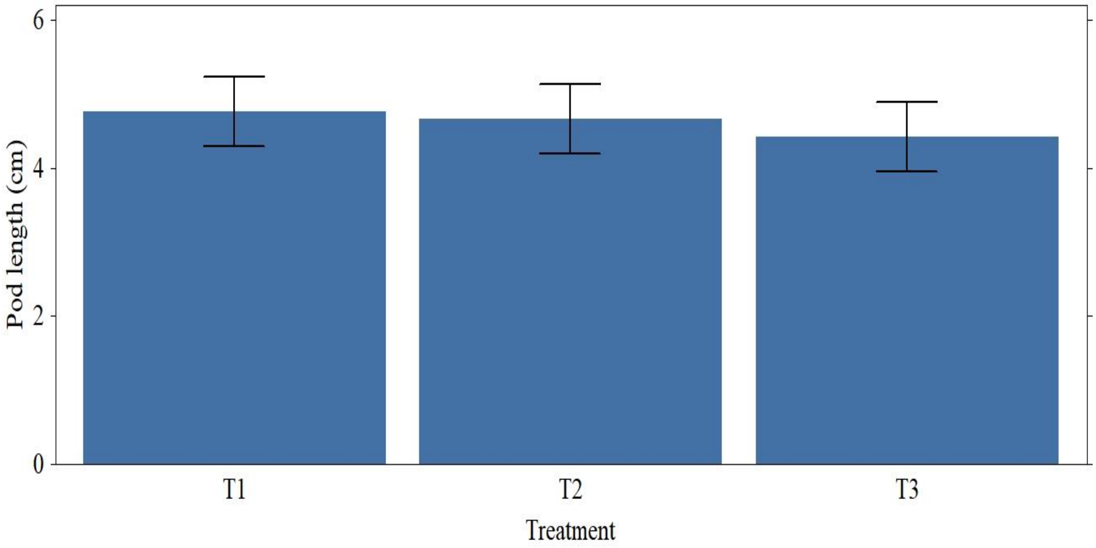


Figure 23: Pod's length after harvest (cm) regarding urea fertilizer application

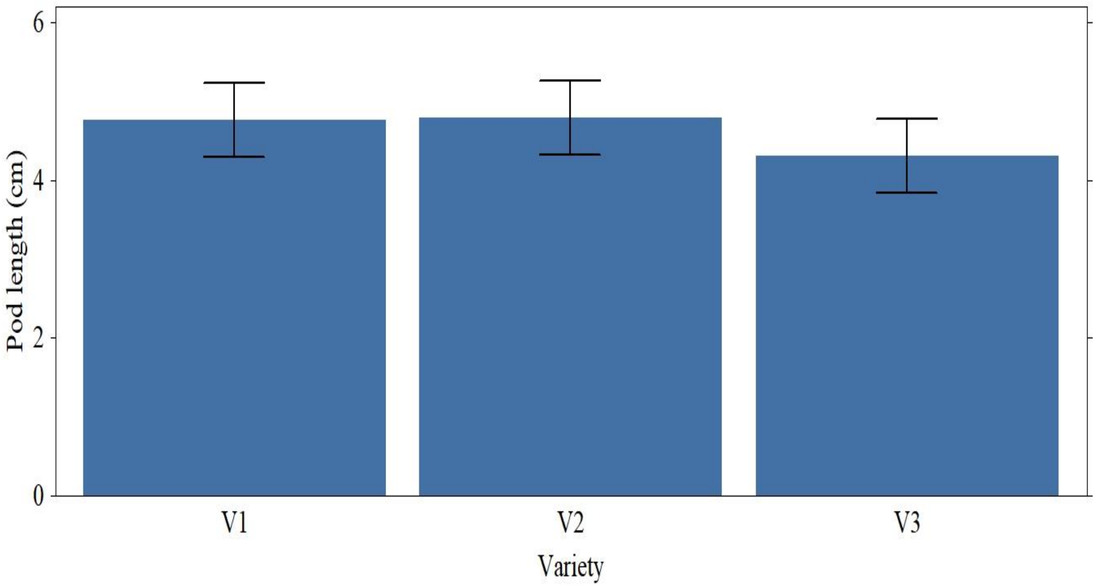


Figure 24: Pod's length after harvest (cm) regarding varieties

Table 12: Interaction of urea fertilizer and varieties pod's length after harvest (cm)

Urea fertilizer and varieties		Pod's length after harvest (cm)
T1	V1	4.85
	V2	4.86
	V3	4.55
T2	V1	5.34
	V2	4.52
	V3	4.13
T3	V1	4.072
	V2	4.96
	V3	4.23
$LSD_{0.05}$		1.7719
Significance Level		NS
CV%		13.20

CHAPTER V

SUMMARY AND CONCLUSIONS

The experiment was conducted at the research field of the Department of Agricultural Botany, Sher-e Bangla Agricultural University, Dhaka during the period from November 2019 to February 2020 to observe the effect of high doses urea on three different cultivars of mustard (BARI sarisha-11, BARI sarisha-16 and BARI sarisha-17). Data on different morphological parameters, different yield and yield contributing parameters and some physiological parameters were recorded.

5.1 Summary of the study

The effect of interaction between cultivars and urea fertilizer on plant height was significant. The tallest plant (179.97 cm) was found in BARI Sarisha-16 when treated with 250 kg/ha urea (T1V2) at harvest. The lowest (70.09 cm) in BARI Sarisha-17 when treated with 375kg/ha urea (T3V3). The combined effect of levels and variety also had non-significant effect on the number of branches per plant. The highest observation (7.46) was seen in BARI sarisha-11 under treatment T1 (250 kg /ha). The lowest observation (6.63) was observed in BARI sarisha-16 under treatment T1 (250 kg/ha). The interaction effect between varieties and N fertilizer were statistically significant. The highest value (42.33) was observed in BARI sarisha-11 under treatment T3 (375 kg/ha). The minimum value (27.16) was seen BARI sarisha-17 under treatment T2 (250 kg/ha). The combined effect between varieties and urea fertilizer was statistically significant. The highest number of flowers (20.10) was seen in BARI sarisha-16 under treatment T1 (250 kg/ha and also in BARI sarisha-16 under treatment T3 (375 kg/ha). A minimum number of flowers (6.33) was observed in BARI sarisha-17 under T1 (250 kg/ha). Combination effect of urea fertilizer and variety has given a significant effect in respect of siliqua number per plant. The maximumm (180.55) number of siliquae was seen in BARI sarisha-16 under T3 (375 kg/ha) and minimum number (59.11) was seen in BARI sarisha-17 under T1 (250 kg/ha). The combined effect of urea fertilizer and varieties created a significant variation in plant dry weight. The highest weight (6.98 gm) was found in BARI sarisha-11 under T2 (312.50 kg/ha).

The lowest weight (4.00 gm) gained by plants was weighted in BARI sarisha-16 T2 (312.50 kg/ha). The Combined effect of urea and varieties on SPAD reading was statistically non-significant. The highest SPAD reading was recorded in BARI sarisha-16 under T3 (375 kg/ha) and the lowest SPAD reading (36.66) was recorded in BARI sarisha-16 under T2 (312.50 kg/ha). The combined effect of different levels of nitrogen and varieties was significant. The Highest LPR value (380.95) was observed in BARI sarisha-11 under T1 (250 kg/ha). The lowest LPR value (161.47) was found in BARI sarisha-17 under T3 (375 kg/ha). The combined effect of nitrogen and variety created a significant variation in seed dry weight. The highest weight (13.52gm) was found in BARI sarisha-11 under treatment T3 (375 kg/ha). The lowest weight (9.08gm) gained by plants was weighted in BARI sarisha-17 T2 (250 kg/ha). Interaction effect of urea and varieties over number of seeds per siliqua was significant. The highest quantity (25.39gm) was found in BARI sarisha-17 under T3 (375 kg/ha). The lowest quantity (12.70 gm) was observed in BARI sarisha-11 under T3 (375 kg/ha). The combined effect of nitrogen and variety had a non-significant effect on five pod’s length. The highest length (5.34 cm) was observed in BARI sarisha-11 under T2 (312.50 kg/ha) and the lowest length (4.13 cm) was observed in BARI sarisha-17 under T2 (312.50 kg/ha).

5.2 Conclusion

Highest plant height at harvest was recorded 131.86 cm under T1 (Bangladesh Agricultural Research Institute recommended dose). Lowest plant height was observed 100.59 cm under treatment T3. Overdoes of urea may have a negative impact on plant height. Highest number of branches and was seen 1.73, 4.58, 7.00 at 20 DAS, 45 DAS and 60 DAS respectively under different treatments. Highest number of leaves was recorded 4.10, 12.93, and 38.43 at 20 DAS, 45 DAS and 60 DAS respectively under T3. So, we can see that plant became bushy when excess amount of urea was applied. Probably overdoses of nitrogen increase vegetative growth of mustard plant. Different levels of urea had also significant effect on seed per siliqua. Highest number of seed per siliqua (21.44) was observed under recommended dose. Probably higher doses of urea had detrimental effect on seed yield. Non-significant relationship was found in case of seed dry weight and pod length. So the overall impact on yield components was non-significant. The effect of different levels of urea application had a significant impact on physiological parameters. SPAD reading and Leaf porometer showed significant variations. The highest SPAD reading (49.88) was recorded under T3 and highest Leaf porometer reading (336.95) was recorded under T1. So, overall, it can be concluded that higher doses of urea had positive impact on plant vegetative growth but it has a detrimental effect on mustard yield. Bangladesh Agricultural Research Institute recommended dose (250 kg/ha) was found most appropriate for BARI sarisha-11, BARI sarisha-16, BARI sarisha-17.

Further experiment can be done in different locations under different environmental conditions by using different levels of nitrogenous fertilizes.

CHAPTER VI

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APPENDIX

Appendix I. Soil nutrient contents of the experimental site.

Characteristics	Value
Ph	5.7
Organic matter (%)	2.35
Total N	0.12
K (me/1000gm soil)	0.17
P (me/1000gm soil)	8.9
S (me/1000gm soil)	30.55
B (me/1000gm soil)	0.62
Fe (me/1000gm soil)	310.4
Zn (me/1000gm soil)	4.82

Source: Soil Resource Development Institute (SRDI), Krishi Khamar Sharak, Dhaka

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2019 to February 2020.

Year	Month	Air Temperature (°C)			Relative Humidity (%)	Rainfall (mm)
		Max.	*Min.*	*Mean*		
2019	November	28.6	8.52	18.56	56.75	14.4
2019	December	25.5	6.7	16.1	54.8	0
2020	January	23.8	11.7	17.75	46.2	0
2020	February	22.75	14.26	18.51	37.9	0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Plant height of mustard plants on different day's interval

Urea fertilizer and varieties		Plant height at 20 DAS	Plant height at 45 DAS	Plant height at 60 DAS	Plant height during harvest
T1		31.66	70.70	98.71	131.86 a
T2		33.73	65.57	96.68	113.48 b
T3		31.62	70.44	94.67	100.59 c
LSD 0.05		3.79	6.21	4.74	4.87
Significance Level		NS	NS	NS	**
CV%		9.64	7.41	4.03	3.47
Variety					
V1		32.13 ab	69.11 b	102.66 b	112.12 b
V2		35.67 a	77.94 a	118.68 a	150.62 a
V3		29.22 b	59.67 c	68.74 c	83.19 c
LSD 0.05		3.79	6.21	4.74	4.87
Significance Level		**	**	**	**
CV%		9.64	7.41	4.03	3.47
Combined effect of treatment and variety					
T1	V1	29.00 abc	68.86 bcd	100.63 cd	122.14 c
	V2	38.00 a	85.70 a	131.13 a	179.97 a
	V3	28.00 bc	57.53 d	64.37 e	93.47 de
T2	V1	31.00 abc	63.33 cd	98.80 d	99.44 d
	V2	36.20 ab	69.20 bcd	111.83 bc	155.00 b
	V3	34.00 abc	64.20 bcd	73.40 e	86.00 e
T3	V1	36.40 ab	75.13 abc	108.53 bcd	114.78 c
	V2	32.80 abc	78.93 ab	113.07 b	116.89 c
	V3	25.66 c	57.26 d	68.47 e	70.09 f
LSD 0.05		9.06	14.84	11.33	11.645
Significance Level		**	**	**	**
CV%		9.64	7.41	4.03	3.47

Appendix IV. Number of branches of the mustard plants on different day's interval

Urea fertilizer and varieties		No of branches 20 DAS	No of branches 45 DAS	No of branches 60 DAS
T1		1.41 b	4.01 b	7.00
T2		1.08 c	4.58 a	7.00
T3		1.73 a	2.92 c	6.97
LSD $_{0.05}$		0.2796	0.4086	0.4615
Significance Level		**	**	NS
CV%		16.28	8.74	5.42
Variety				
BARI sarisha-11		1.93 a	4.02 a	6.95
BARI sarisha-16		1.73 a	3.40 b	6.90
BARI sarisha-17		0.56 b	4.10 a	7.10
LSD $_{0.05}$		0.2796	0.4086	0.46
Significance Level		**	**	NS
CV%		16.28	8.74	5.42
Combined effect of treatment and variety				
T1	V1	2.20 ab	4.00 b	7.46
	V2	1.73 bcd	3.60 bc	6.63
	V3	0.30 f	4.43 b	6.90
T2	V1	1.10 de	4.26 b	6.80
	V2	1.46 d	2.90 c	7.13
	V3	0.70 ef	6.60 a	7.06
T3	V1	2.50 a	3.80 bc	6.60
	V2	2.00 abc	3.70 bc	7.00
	V3	0.70 ef	1.26 d	7.33
LSD $_{0.05}$		0.6678	0.9760	1.1025
Significance Level		**	**	NS
CV%		16.28	8.74	5.42

Appendix V. Number of leaves of mustard plant on different day's interval

Urea fertilizer and varieties		No of leaves at 20 DAS	No of leaves at 45 DAS	No of leaves at 60 DAS
T1		3.44	11.72	34.07 ab
T2		4.00	11.63	30.55 b
T3		4.10	12.93	38.43 a
LSD $_{0.05}$		0.6947	1.5842	5.3036 to 5.5467
Significance Level		NS	NS	**
CV%		14.84	10.76	12.60
Variety				
V1		3.60	12.94 a	37.91 a
V2		4.10	12.57 a	35.58 a
V3		3.84	10.76 b	29.57 b
LSD $_{0.05}$		0.6947	1.5842	5.3036 to 5.5467
Significance Level		NS	*	**
CV%		14.84	10.76	12.60
Combined effect of treatment and variety				
T1	V1	3.43 ab	11.46 bc	35.86 a
	V2	3.80 ab	13.20 ab	39.20 ab
	V3	3.10 b	10.50 bc	27.16 b
T2	V1	3.16 b	15.46 a	35.53 ab
	V2	3.90 ab	10.93 bc	27.93 b
	V3	4.93 a	8.50 c	28.20 b
T3	V1	4.20 ab	11.90 abc	42.33 a
	V2	4.60 ab	13.60 ab	39.60 ab
	V3	3.50 ab	13.30 ab	33.36 ab
LSD $_{0.05}$		1.6595	3.7842	12.688 to 14.362
Significance Level		**	**	*
CV%		14.84	10.76	12.60

Appendix VI. Number of flowers and siliqua of mustard plant on different DAS

Urea fertilizer and varieties		No of flowers on at 20 DAS	No of flowers at 45 DAS	No of siliqua at harvest
T1		2.33 b	13.83 b	124.19 b
T2		2.46 ab	10.51 c	131.96 ab
T3		2.84 a	15.22 a	136.18 a
LSD $_{0.05}$		0.4940	1.2940	8.64
Significance Level		*	**	**
CV%		15.93	8.06	5.43
Variety				
V1		2.71	15.75 a	155.46 b
V2		2.68	16.96 a	168.76 a
V3		2.24	6.84 b	68.11 c
LSD $_{0.05}$		0.4940	1.2940	8.64
Significance Level		NS	**	**
CV%		15.93	8.06	5.43
Combined effect of treatment and variety				
T1	V1	2.46 ab	15.06 bc	143.83 c
	V2	2.86 a	20.10 a	169.62 ab
	V3	1.66 b	6.33 d	59.11 e
T2	V1	2.53 ab	12.46 c	158.00 bc
	V2	2.33 ab	12.66 c	156.11 bc
	V3	2.53 ab	6.40 d	81.78 d
T3	V1	3.13 a	19.73 a	164.56 ab
	V2	2.86 a	18.13 ab	180.55 a
	V3	2.53 ab	7.80 d	63.44 de
LSD $_{0.05}$		1.1801	3.0911	20.641
Significance Level		*	**	**
CV%		15.93	8.06	5.43

Appendix VII. Plant dry weight, seed dry weight & no of seed per siliqua

Urea fertilizer and varieties		Plant dry weight (gm)	Seed dry weight (gm)	Number of seed per siliqua
T1		6.03	11.35	21.44 a
T2		5.88	12.18	17.69 b
T3		6.03	12.55	17.81 b
LSD $_{0.05}$		1.0454	2.9609	1.8787
Significance Level		NS	NS	**
CV%		14.35	20.23	8.13
Variety				
V1		6.67 a	13.42	25.37 a
V2		5.20 b	11.60	16.07 b
V3		6.08 ab	11.05	15.50 b
LSD $_{0.05}$		1.0454	2.9609	1.8787
Significance Level		**	NS	**
CV%		14.35	20.23	8.13
Combined effect of treatment and variety				
T1	V1	6.32 ab	13.60	20.71 bc
	V2	6.89 a	11.36	18.10 cd
	V3	4.90 ab	9.08	25.53 a
T2	V1	6.98 a	13.15	13.10 e
	V2	4.00 b	11.27	14.80 de
	V3	6.67 a	12.11	25.17 ab
T3	V1	6.73 a	13.52	12.70 e
	V2	4.70 ab	12.15	15.33 de
	V3	6.67 a	11.97	25.39 a
LSD $_{0.05}$		2.4972	7.0730	4.4878
Significance Level		**	NS	**
CV%		14.35	20.23	8.13

Appendix VIII. Five Pod's length after Harvest, SPAD reading, LPR, Temperatures

Urea fertilizer and varieties		5 pod's length after harvest (cm)	SPAD reading	LPR	Temperature
T1		4.76	43.81 b	336.95 a	31.000
T2		4.66	43.75 b	301.51 b	30.933
T3		4.42	49.88 a	195.47 c	31.022
LSD $_{0.05}$		0.7418	5.9655	30.182	0.4275
Significance Level		NS	**	**	NS
CV%		13.20	10.70	8.92	1.13
Variety					
V1		4.78	47.37	330.97 a	30.96
V2		4.75	45.83	264.99 b	30.84
V3		4.30	44.24	237.97 b	31.14
LSD $_{0.05}$		0.7418	ns	30.182	0.4275
Significance Level		NS	5.9655	**	NS
CV%		13.20	10.70	8.92	1.13
Combined effect of treatment and variety					
T1	V1	4.85	46.50 ab	380.95 a	30.93
	V2	4.86	46.13 ab	252.00 b	30.83
	V3	4.55	38.80 b	377.90 a	31.23
T2	V1	5.34	47.93 ab	377.87 a	31.00
	V2	4.52	36.66 b	352.13 a	30.80
	V3	4.13	46.66 ab	174.53 cd	31.00
T3	V1	4.072	47.70 ab	234.10 bc	30.96
	V2	4.96	54.70 a	190.83 bcd	30.90
	V3	4.23	47.26 ab	161.47 d	31.20
LSD $_{0.05}$		1.7719	14.250	72.099	1.0212
Significance Level		NS	**	**	NS
CV%		13.20	10.70	8.92	1.13

PLATES

Plate 1. Photographs show seeds, prepared seedbed and emergence of seed

Plate 2. Irrigation to the plants

Plate 3. Data collection

Plate 4. Harvested and threshing of the mustard plants

Plate 5. Photographs of seed after harvest