RESPONSE OF MUSTARD VARITIES TO DIFFERENT NITROGEN MANAGEMENT

ROJINA AKTER

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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BY
ROJINA AKTER

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Approved by:

Dr. Md. Fazlul karim	Dr. Md. Hazrat Ali
Professor	Professor
Supervisor	Co-Supervisor

Dr.Md. Ruhul Amin
Chairman
Examination Committee

Dr. Md. Fazlul karim
Professor
Department of Agronomy
Sher-e Bangla Agricultural University
Dhaka-1207, Bangladesh

CERTIFICATE

*This is to certify that thesis entitled, "**RESPONSE OF MUSTARD VARETIES UNDER DIFFERENT NITROGEN MANAGEMENT**" 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 AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **ROJINA AKTER** Registration No. **08-3223** 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.

Dated:
Place: Dhaka, Bangladesh

(Dr. Md. Fazlul karim)
Supervisor

ABBREVIATIONS

The following abbreviations have been used throughout the thesis

AEZ	: Agro Ecological Zone
%	: Percent
Agric.	: Agriculture
Agril.	: Agricultural
Agron.	: Agronomy
BAU	: Bangladesh Agricultural University
BBS	: Bangladesh Bureau of statistics
BINA	: Bangladesh Institute of Nuclear Agriculture
CGR	: Crop growth rate
cm	: Centimeter
CV	: Coefficient of Variation
DMRT	: Duncans New Multiple Range Test
et al.	: And other/ and elsewhere/ Associates
g	: Gram
HI	: Harvest Index
J.	: Journal
Kg ha^{-1}	: Kilogram per hectare
LSD	: Least Significant Difference
m	: Meter
mg	: Milligram
MOP	: Muriate of potash
N	: Nitrogen
NS	: Not significant
p.	: Page
Res.	: Research
RGR	: Relative growth rate
Sci.	: Science
Soc.	: Society
t ha^{-1}	: Ton per hectare
TDM	: Total Dry Matter
TSP	: Triple super phosphate
Univ.	: University
USG	: Urea Super Granule
Var.	: Variety

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SAU,Dhaka

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ABSTRACT

The experiment was carried out at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from November 6, 2009 to February 10, 2010 to asses the comparative advantages of using urea super granule (USG) over prilled urea and also the effect of different management of nitrogenous fertilizer on growth, yield and yield attributing characters of mustard. Four nitrogen Treatment (T_1= Normal urea, T_2 = USG as basal, T_3 = USG at 15 DAS and T_4 = USG at 25 DAS) and three mustard varieties (BARI Sarisha-11, BARI Sarisha-13 and BARI Sarisha-14) were used as treatment variables in the experiment. The experiment was laid out in a split plot design with 3 replications. Results indicate that the plant growth characters, yield and yield attributes of the cultivars were significantly influenced by USG application. Plant height, number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, total dry matter, number of siliqua plant^{-1}, siliqua length, number of seed siliqua-1, 1000-seed weight, and seed yield (t ha^{-1}) were found highest when USG was applied as basal dose and all the characters showed lowest value when USG was applied at 25 DAS. Highest number of siliqua per plant (654.7) and yield (2.06 t ha^{-1}) was obtained in BARI Sarisha 11 when USG was used as basal dose which reduce 40% use off prilled and 20% of total cost in mustard cultivation.

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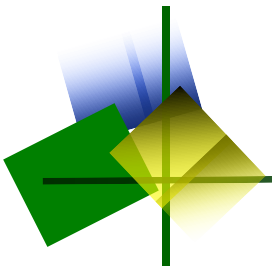


CHAPTER 1

INTRODUCTION

CHAPTER I

INTRODUCTION

Oil seed crops are grown in 338.0 thousand hectares in Bangladesh which is 2.47% of the cultivable land (BBS 2008). Although about seven oilseed crops are grown in the country but mustard (*Campestris and Juncea*) alone occupies about 70% of the oilseed land followed by sesame, (*Sesamum indicum*) groundnut (*Arachis hypogaea*), linseed (*Linum usitatissimum*), soybean, sunflower and niger(BBS 2008).

Rapeseed and mustard belong to Cruciferae family and genus Brassica. Rapeseed is locally called as sarson, toria, yellow toria, whereas, mustard is called as rai or laha. Though, rapeseed and mustard belong to the same family and genus, they differ with respect to their plant characteristic

Bangladesh is facing acute shortage in edible oil. In Bangladesh more than 134.875 thousand metric ton of local rape and mustard is produced from total 392.900 thousand acre of cultivable land and about 540.005 thousand metric ton of hybrid rape and mustard produced from total 127.145 thousand acre of cultivable land in the year 2006-2007, Which meets only 11.2% of total demand of the country (BBS, 2008). It is used as condiment, salad, green manure and fodder crop and leaf and stem as vegetables in the various mustard growing countries of the world Mustard oil is mainly used for edible purpose and apart finds industrial applications. Oil cake is used as manure and animal feed. It is mainly self-pollinating crop, although on an average 7.0 to 30% out-crossing does occur under natural field conditions (Abraham, 1994; Rakow and Woods, 1987).

The area and production of oilseeds are gradually declining due to (i) Low yield potential of oilseed varieties (ii) High infestation of diseases and pests, compared to other crops (iii) Instability of yield due to micro-climatic fluctuation (iv) Expansion of irrigation facilities and more profitable crops are available in place of in the cropping patterns. Most oilseeds crops respond positively with high management, yet they cannot compete with other high value crops. Usually, farmers do not allocate their good piece of land and also they do not follow modern cultural practices for oil crops. So, their yields are low.

Almost all oilseed crops grow throughout the country is under specific niches and cropping patterns. Such as Tori-7 mustard is grown largely in between Aman and Boro rice. Oil seeds have been pushed down to marginal land due to increased area under boro rice, wheat and maize, as a result lower yield is obtained. So, the modern variety with mustard growing area need to be expanded by replacing the low yielding local cultivars and the seed yield per unit area is needed to be increased. There is a great scope to improve the yield of mustard per unit area with the use of fertilizers.

High yielding varieties of mustard are very responsive to fertilizers, particularly nitrogen. It is also responsive to nitrogenous fertilizer more under irrigated condition than under rainfed condition (Islam *et al*.,1992). It encourages the flow of assimilates to flowers and developing siliqua and ultimately the seed. But the nitrogen reserve of Bangladesh soil is very low due to warm climate accompanied by centuries of cultivation in the same piece of land (Porteh and Islam, 1984).On the other hand, deficiency of nitrogen also hampers the production of mustard. Therefore, energy and high costs of fertilizer nutrients necessitate economizing their use. The recovery of applied nitrogen is low due

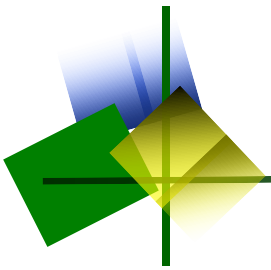
to several loss process operating in the field. Split application of fertilizer suggested for increasing nitrogen use efficiency is often not practical due to adverse soil water situations. Hence ,the entire amount of nitrogen required to be applied in single broadcast application when the water regime is favorable. A single broadcast application however increase nitrogen loss. Deep placement of urea super granule (USG) has been proved to improve nitrogen use efficiency .The placement technology is best suited to conditions where predominant nitrogen loss mechanism is ammonia volatilization rather than leaching or denitrification. Deep placement of USG thus has greater benefit over surface split application with moderate to heavy textured soil, low permeability and percolation rate, and high cataion exchange capacity (Mohanty *et al*., 2007)

Urea super granule is a slow release nitrogen fertilizer and farmers have adopted it in boro rice cultivation. It was assumed that application of USG could be also profitable in different upland vegetables, fruits and oil seeds crops. According to Creswell and De Datta (1980) broadcast application of urea on the surface soil causes loss upto 50% but point placement of USG in 10 cm depth can save 30% nitrogen than prilled urea, increase absorption sate, improve soil health and ultimately increase yield (Savant et al., 1991)

Virtually there has been very scanty/minimum research works done so far in digging into farmer's interaction and efficiency differences between the USG and PU users at end users level. Taking into consideration of all these issues, the present study was undertaken to achieve the following objectives-

i. To evaluate the efficiency and advantages of using USG over prilled urea with respect to yield and yield attributes of mustard.

ii. To study the varietal performance with different nitrogen management.



CHAPTER 2

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Cruciferous *Brassica* is one of the common and most important oil crops of Bangladesh and as well as many country of the world. In Bangladesh the average productivity of mustard is low in comparison to the developed countries. The crop has received much attention by the researchers on various aspects of its production. Many studies have been carried in many countries of the world. The work so far done in Bangladesh is not adequate and conclusive. Nevertheless some of the important and informative works and research findings about urea super granules have been reviewed in this chapter .

Humphreys *et al.* (2006) reported that recovery of nitrogen from point placement of urea of super granule was 49% higher than prilled urea. The increase in plant nitrogen recovery consequently increases plant height, number of leaf , tillering and a yield or agronomic efficiency of rice plant.

Suhartatik (1991) reported that point placement of urea super granule with lime significantly increased the leaf area index (LAI) of mungbean.

Sardana and Verma (1987) conducted an experiment in New Delhi, India in 1983-84 and reported that larger urea granule causes slow release of nitrogen and results significant increase in leaf are index (LAI) of mungbean.

Saikia *et al.* (2002) reported the response of Indian mustard cv. Pusa giant grown in New Delhi, India during rabi season of 1998-99. They found that those varieties response positively to the use of USG than prilled urea and neem coated urea.

Alam *et al. (2000)* carried out a socio economic study in two rice production environment (Gazipur and Tangail) to assess the comparative advantages of using urea super granule (USG) over prilled urea (PU) in modern rice production and to examine the differences in producers technical efficiency between USG urea and non user in crop management. Results revealed that comparatively low amount (36%) of urea was needed in modern boro rice production using USG instead of PU though 15% more labour was needed while weeding cost was a bit lower in USG using plots. Results also indicated additional yield of 0.87 t/ha by using USG and this yield gain additional benefit of TK. 11506/ha.

Mahapatra *et al.* (1990) conducted a field experiments in two wet and two dry seasons to evaluate efficiencies of different urea based fertilizers and methods of application for irrigated and rainfed rice. They found that 10% less USG gave significantly superior results than 100% prilled urea .

In recent year a deep understanding on mechanism causing poor utilization help to develop cultural practices to improve nitrogen use deficiency (NUE) in low land rice. Urea super granule (USG) a physical modification of ordinary urea is considered a slowly available N fertilizer and found deficient when properly deep placed (Savant and Stangel, 1990). Deep placement of USG at the rate of 120 kg/ha significantly increased the grain and straw yield over prilled urea. (Das and singh, 1994; Mishra and Gupta, 1995)

Pandey and Tripathi (1994) reported that application of urea super granule at the rate of 112 kg/ha^{-1} significantly improved the yield components like productive tillers, panicle length, fertile spikelets per panicle and 1000 grain weight.

Sudhakara and Prasad (1986) conducted a field experiment in rainy season in 1982-83 at the Indian agricultural Research Institute, New Delhi to study the relative efficiency of prilled urea, urea super granule and neem coated urea. They observed that performance of rice if more or less linear to USG and neem coated USG which were better than prilled urea.

A field experiment was conducted at the farm of BINA during July-November 1999 to study the performance of BINA dhan1 using different sources of urea. The result showed that plant height (141.31 cm) total tillers (13.06 $hill^{-1}$), total dry matter (46.82g $hill^{-1}$), number of filled grains (109.6), grin yield (5.71 tha^{-1}) straw yield (8.20 t ha^{-1}) were significantly higher in the field where USG was used than prilled urea.

Khalil *et al.* (2006) conducted a field experiment to know the recovery of spring wheat with urea super granules. They observed that the translocation of N from vegetative part to grain portion during grain filling stage (67-116 DAA) was 34.9% with the USG and 28.7% with PU, resulting in (711 kg/ha) more grain yield with the former than the later.

Irrespective of urea sizes fertilizer nitrogen recovery in crop increased linearly until 67 or 70. Being highest (75-78%) with the USG point placed at 2.5 cm depth. Results suggest that the USG technique could increase yield and fertilizer use efficiency of spring wheat and decrease gaseous nitrogen losses over the PU

Ahmed *et al.* (2010) conducted a field experiment in farmers field at the MLT site at Madhupur and Ghatail Upzilla with four treatment on the production of hybrid maize. The highest grain yield (10.30t/ha) was obtained from the plot treated with recommended dose of N as USG which was similar to that of plots

treated with 10% less than recommended dose of N as USG (9.44t/ha). The recommended dose of N as Prilled urea gave yield of 9.21t/ha. The maximum gross return (Tk.131428 /ha) was obtained from plots treated with recommended dose of N as USG.

Singh and Mishra (1992-93) conducted a field experiment on a calcareous alluvial sandy loam soil to see the comparative effect of prilled urea and urea super granules on yield and quality of Sugarcane. Use of USG up to 75% of the recommended dose of N increased sugar and sugarcane yields significantly as comparison with prilled urea. Cane juice quality was not affected significantly with these materials. USG was found stimulating ammonification significantly in the soil than priled urea and reduced nitrification significantly.

Yadav *et al.* (1990) nnducted a field experiment at Lucknow on sugarcane. Urea super granules (USG),neem-cake coated urea (NCU), dicyanamide-treated Urea (DCD) and the traditional N source prilled urea (PU) were used to supply 150 kg N/ha. Uptake and recovery of N were significantly greater using USG than NCU, DCD and PU.

Two field experiments were conducted by Rao *et al.* (2004) in Joypur to study the effect of prilled urea, neem coated urea and urea super granules on a perennial aromatic herb, geranium (*Pelargonium graveolens* L Her.) grown on a sandy loam soil. They reported that, application of nitrogen increased the biomass and essential oil yields. USG and neem coated urea significantly increased the yields over prilled urea. The concentration and quality of essential oil were not influenced either by levels or carrier of N.

Singh and Singh (2006) conducted two field experiments for two crop cycles each for two years on an entities over *Citronella Java*. They found that the oil

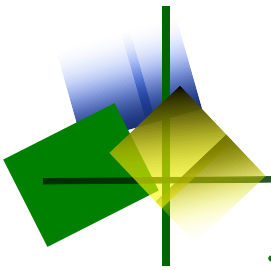
yields were 9% higher in USG than that of PU and N recovery of USG and PU were 31 and 21% respectively.

Haque (1998) conducted a field experiment on potato at BAU farm and farmers field at Madhupur. Four treatment were used (1) Control (without any fertilizer), (2) 100 Kg N/ha from prilled urea, (3) USG, 2; 73 kg N ha^{-1} from USG (4) USG-3; 109 kg N ha^{-1} from USG point placement . USG greatly increased yield of potato tubers both at BAU farm and farmers field at Madhupur. Maximum potato tubers yield at BAU farm was from USG-3 treatment which was 24.16 t/ha compared to 17.52 t/ha from prilled urea application. Maximum yield of potato tubers at farmer's field was obtained from USG-3 treatment which was 26.50 t/ha compared to 20.78 t/ha from same dose of prilled urea application.

Talukder *et al.* (2004) conducted an experiment at Syedpur and Tista meander flood plain to observe the efficiency of Urea super granule on tomato for two years. Two forms of urea i.e. prilled urea and USG were applied. Two years results revealed that USG had significant positive effect on the yield of tomato as compared to prilled urea. The recommended dose of N (150 kg/ha) from USG gave highest marketable fruit yield of 79.13 t/ha in the 1^{st} year and 73.60 t/ha in the 2^{nd} year. They also observed that when 150 kg and 135 kg/ha of N applied from USG gave 11% and 2% higher yield of tomato than that of using 150 kg/ha N from prilled urea, respectively.

Hussian *et al.* (2010) conducted a number of experiments at farming system Research and Development (FSRD) site at Tangail for three consecutive years to evaluate of efficiency of USG application over prilled urea on the yield of cabbage. Five treatments were applied viz (T_1= 195 kg prilled Urea, T_2= 195 kg prilled USG, T_3= 175 kg prilled USG, T_4=155 kg prilled USG, T_5=105 kg

prilled Urea (farmers applied). They reported that, yield and yield contributing characters of cabbage significantly responded to the application of USG. The highest head yield (78.1 t/ha) was obtained with the recommended dose of N as USG. The 10% and 20% reduction i. e. 175 kg USG ha^{-1} and 155 kg USG ha^{-1} also gave higher yield (77.1t/ha, 72.0 t/ha respectively) than that of recommended dose of prilled urea application.



CHAPTER 3

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

A field experiment was conducted at the research field of Agronomy Department of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2009 to February 2010. The materials and methods of this experiment are presented in this chapter under the following headings-

3.1 Experimental Site

The present piece of research work was conducted in the field of Agronomy Department, Sher-e-Bangle Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the site is 23°74'N latitude and 90°35' E longitude with an elevation of 8.2 meter from sea level.

3.2 Characteristics of Soil

The soil of the experimental area was loamy belonging to the Madhupur Tract under AEZ 28. The soil of the experimental plots were clay loam, land was medium high with medium fertility level (Appendix I).

3.3 Weather Condition of the Experimental Site

The geographical situation of the experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon of rainy season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al*. 1979). During the rabi season the rainfall generally is scant and temperature moderate with short day length. Meteorological data on rainfall, temperature, relative

humidity from November 2009 to March 2010 were obtained from the Department of Meteorological centre, Dhaka-1207, Bangladesh (Appendix ii).

3.4 Materials of the experiment

3.4.1 Collection of plant materials

The seeds of mustard varieties were collected from the Division of Agronomy, Bangladesh Agricultural research institute, Gazipur, Bangladesh. The seeds were healthy, vigorous, well matured and free from other crop seeds and inert materials.

3.4.2 Experimental treatments

The experiment was a fertilizer cum variety trial. Nitrogen was the fertilizer element, prilled and USG urea was applied as fertilizer to supply the nitrogen four doses of nitrogen and three mustard varieties were selected for the study. The experiment was designed with two factors:

Factor A : Variety

V1= BARI Sarisha –11

V2= BARI Sarisha –13

V3= BARI Sarisha –14

Factor B: Nitrogen management

T1= Prilled urea application (250 kg ha^{-1})

T2= Application of USG as basal dose (150 kg ha^{-1})

T3= Application of USG at 15 DAS (150 kg ha^{-1})

T4=Application of USG at 25 DAS (150 kg ha^{-1})

3.2.3 Experimental design and layout

The experiment was laid out in a Split plot design with 3 replications. There were a total of 36 unit plots. The size of the unit plot was 4m X 2.5m. Distances between replication to replication and plot to plot were 1m and 0.5 meter, respectively. Plant to plant and row to row distances were maintained 10cm and 30 cm, respectively.

3.2.4 Land preparation

The land of the experimental site was first opened in last week of October with power tiller. Later on, the land was ploughed and cross-ploughed three times followed by laddering to obtain the desired tilth. The corners of the land were spaded and larger clods were broken into smaller pieces after ploughing and laddering all the stubbles and uprooted weeds were removed and the land was made ready.

3.2.5 Fertilizer application

Triple super phosphate (TSP =180 kg ha^{-1}) Muriate of potash (MoP=120 kg ha^{-1}), Gypsum (180 kg ha^{-1}) and Borax (10 kg ha^{-1}) were used as source of phosphorus, potassium, sulphur and boron, respectively. Total amount of TSP, MoP, gypsum, borax and were applied as basal doses during final land preparation of all plot. Half of prilled urea was applied during final land preparation and rest half was applied before flowering (52 DAS) for prilled area treatment. In USG treatment, USG placed in alternate rows maintaining distance 10 cm in each row and placed at a depth of 5 cm.

3.2.6 Weeding

Hand weeding was done two times at 15 and 30 days after sowing.

3.2.7 Harvesting and processing

The crop was harvested when more than 80% siliqua were riped 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. Straw weight were recorded after oven drying. Seed weight was recorded after 3 days sun drying.

The morphological parameters were recorded:

i. Plant height

ii. Number of leaves plant^{-1}

iii. Number of primary branches plant^{-1}

iv. Number of secondary branches plant^{-1}

Growth parameters were recorded:

i. Total dry matter

ii. Leaf area

Yield and yield attributes parameters were recorded:

i. number of siliqua plant^{-1}

ii. Number of seed siliqua^{-1}

iii. Length of siliqua

iv. 1000-seed weight

v. seed yield tha^{-1}

3.2.8 Crop sampling and data collection

To study ontogenetic growth characteristics, a total of four harvests were made and at final harvest, data were collected on some morphological, yield and yield attributes. The first crop sampling was done at 35 DAS and continued at an interval of 10 days up to 65 DAS and at maturity (85 DAS). From each plot ten plants were randomly selected and uprooted for obtaining data of necessary parameters. The plants were separated into leaves, stems and roots and the corresponding dry weights were recorded after oven drying at 80°C for 72 hours. The leaf area of each sample was measured by LICOR automatic leaf area meter.

3.2.9 Morphological characters

i. Plant height (cm)

The height of the plants at 30, 45, 60 days and at maturity were measured from the base of the plant to the tip of the main stem and mean value of the plants were finally recorded.

ii. Number of leaves plant^{-1}

Number of leaves plant^{-1} was recorded from three plants of each treatment and mean value was calculated.

iii. Number of primary and secondary branches plant^{-1}

The number of primary and secondary branches were counted plant^{-1} and mean value was taken.

3.2.10 Growth parameters

i. Leaf area plant^{-1} (cm^2)

All leaves of a plant were cut with sharp blade. Their area was then measured with a LICOR automatic leaf area meter.

ii. Total dry matter (TDM)

The total dry matter was calculated from summation of leaves, stem, root and pod dry weight plant^{-1}.

4.1 Yield and yield contributing characters

i. Number of siliqua plant^{-1}

Siliqua of three randomly selected plants of each plot were counted and then the average number of siliqua for each plant was determined.

ii. Siliqua length (cm)

Siliqua length was recorded from the base to the apex of each siliqua from randomly selected 10 siliqua of each treatment and then means value was calculated.

iii. Seeds siliqua^{-1}

After shedding of the siliqua seed numbers was recorded from each siliqua and finally mean value was calculated.

iv. 1000- seed weight

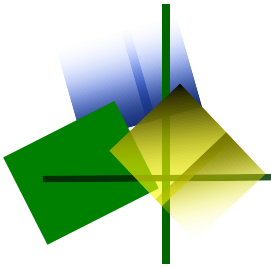
One thousand clean sun dried seeds were counted from the seed stock obtained from the sample plants and weighed by electronic balance and expressed in g.

V. Seed yield (tha^{-1})

Total mustard plants were collected from pre selected area (2 m^2) of the middle of each plot .The plants were cut, threshed and dried. The dried seeds were weighed.Then the weighed seed yield was converted to tha^{-1}.

5. Statistical analysis:

Collected data were analysed using computer package program MSTAT-C by Duncan's new multiple range testing at 5% level of significance.



CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

Effect of different levels of nitrogen on the growth and yield components of three mustard cultivars were studied in the present experiment. For the convenience of easy understanding the results have been presented and discussed under following sub-headings:

4.1 Effect of different N treatments on morphological characters of mustard

4.1.1 Plant height (cm)

There were significant variations in plant height among cultivars (Table 1). At maturity the highest plant height (142.4 cm) was observed in BARI Sarisha 11 which was followed by BARI Sarisha 13 (104.6 cm) and BARI Sarisha 14 (83.60 cm). This variation in plant height might be attributed to their genetic characters. The results are agreement with the findings of Shamsuddin *et al*. (1987) and Mondal and Gaffer (1983). They reported that different varieties of mustard differed significantly in plant height.

Plant height was significantly influenced by the application of N-fertilizer (Table 1). Significantly highest plant height (117.2 cm) was found in USG basal dose (T_2).The lowest (104 cm) plant height was recorded in USG 25 DAS (T_4) and it was statistically identical with T_3 treatment . These findings corroborated with the results reported by Rahman (2003), Hasan and Rahman (1989), Shamsuddin *et al*. (1987) and Mondal and Gaffer (1983). They found that the application of N increased the plant height significantly.

The effect of interaction between cultivars and N-fertilizer on plant height was significant (Table 1). The tallest plant (154.2 cm) was found in BARI Sarisha 11

when treated with USG Basal dose (V_1T_2) at maturity which was significantly different from all other treatments. The lowest (81.34 cm) at BARI Sarisha 14 when USG was applied at 25 DAS (V_3T_4) and it was statistically identical with V_3 T_1, V_3T_2 and V_3T_3 treatments.

Number of leaves per plant^{-1}

There were significant variations among varieties in respect of number of leaves per plant^{-1}. Highest numbers of leaves plant^{-1} (13.94) were found in BARI Sarisha 14, which was statistically similar to BARI Sarisha 11 (13.44). The lowest number of leaves plant^{-1} (9.64) was counted from BARI Sarisha 13 and it was statistically identical with BARI Sarisha 11. Significant difference in the number of leaves plant^{-1} was also noted due to variation in nitrogen management (Table 1).

Application of USG as basal dose gave significantly highest (14.32) number of leaves plant^{-1} which was significantly different from all other treatments. USG at 15 DAS (11.50) and USG at 25 DAS (10.99) gave statistically identical of leaves plant^{-1} .Interaction effect of mustard varieties and nitrogen management also varied significantly (Table 1).The highest number of leaves per plant (16.73) was recorded from BARI Sarisha 14 when treated with USG as basal dose and the lowest from V_2T_4 (8.53), V_2T_3 (8.90) and V_2T_1 (9.83) managements, respectively. However, there were no significant variation found among these three treatments.

4.1.3 Number of primary and secondary branches plant^{-1}

There were no significant variations among varieties in terms of primary and secondary branches plant^{-1}(Table 1). The effect of nitrogen treatments on number of branches plant^{-1} was found significant (Table 1). The highest number of primary (6.36) and secondary (12.27) branches plant^{-1} was recorded at USG basal dose (T_2). The lowest number of primary (5.08) and secondary (6.62) branches plant^{-1} was found in USG at 25 DAS (T_4). The result of the present investigation was similar to the findings reported by Patil *et al*. (1996), Khanpara *et al*. (1992) and Murtuza and Paul (1989). The interaction effect between varieties and N fertilizer managements were statistically similar. Number of primary and secondary branch was highest in V_3T_2 (7.77) and V_1T_2 (15.90) treatments respectively and the lowest from V_1T_4 (4.30) and V_2T_4 (4.73) treatments respectively.

4.2 Effect of different levels of nitrogen on growth parameter

4.2.1 Leaf area plant^{-1} (cm^2)

Leaf area differ significantly plant^{-1} due to varieties (Table 1). The highest leaf area (204.0 cm^2) was noted in BARI Sarisha 13 and it was statistically identical with BARI Sarisha 11 (201.6 cm^2). The lowest leaf area (21.55 cm^2) was noted in BARI Sarisha 14. Leaf area showed significant difference due to variation in N management. The highest leaf area (191.8 cm^2) was found in USG basal dose (T_2) and it was significantly different from all other treatments. Interaction effect of mustard varieties and N management showed significant difference on leaf area plant^{-1} (Table 1). BARI Sarisha 13 with USG application as basal dose (V_2T_2) gave the highest (276.7cm^2) leaf area plant^{-1}, which was statistically similar to BARI Sarisha 11 with USG application as basal dose (V_1T_2). The lowest area (16.63 cm^2) was noted in BARI Sarisha 14 with USG application at 25 DAS (V_2T_2), but treatment V_3T_1 (21.13 cm^2), V_3T_2 (29.40 cm^2) and V_3T_3 (19.03 cm^2) were statistically similar.

Table 1: Main and interaction effects of varieties and N-fertilizer treatments on the plant height, no.of leaves plant^{-1}, no. of primary and secondary branches plant^{-1} and leaf area

Treatments	Plant Height (cm)	No. of Leaf plant^{-1}	No. of Primary Branches plant^{-1}	No. of Secondary Branches plant^{-1}	Leaf Area (cm^2)
Variety					
BARI Sarisha 11(V_1)	142.4 a	13.44	5.03	11.27	201.6 a
BARI Sarisha 13(V_2)	104.6 b	9.64	5.30	7.10	204.0 a
BARI Sarisha 14(V_3)	83.60 c	13.94	6.68	10.88	21.55 b
S-$_x$	1.048	NS	NS	NS	14.13
CV %	3.29	29.07	38.82	69.98	34.38
Fertilizer level					
Normal Urea (T_1)	111.9 b	12.53 b	5.86 b	10.80 ab	156.4 b
USG Basal (T_2)	117.2 a	14.32 a	6.36 a	12.27 a	191.8 a
USG 15 DAS(T_3)	107.8 c	11.50 c	5.37 c	9.32 b	116.2 c
USG 25 DAS(T_4)	104.0 c	10.99 c	5.08 c	6.62 c	105.1 c
S-$_x$	1.36	0.28	0.11	0.59	4.94
CV %	3.70	6.77	5.85	18.18	10.40
Combined of Variety and Fertilizer treatment					
V_1T_1	144.6	13.60	5.40	12.80	215.4 b
V_1T_2	154.2	14.93	5.70	15.90	269.3 a
V_1T_3	139.4	13.04	4.70	10.17	166.7 c
V_1T_4	131.5	12.17	4.30	6.23	155.1 c
V_2T_1	106.6	9.83	5.43	7.77	232.8 b
V_2T_2	111.3	11.30	5.60	9.00	276.7 a
V_2T_3	101.4	8.90	5.15	6.88	162.8 c
V_2T_4	99.10	8.53	5.00	4.73	143.6 c
V_3T_1	84.35	14.17	6.73	11.83	21.13 d
V_3T_2	85.97	16.73	7.77	11.90	29.40 d
V_3T_3	82.73	12.53	6.27	10.90	19.03 d
V_3T_4	81.34	12.28	5.93	8.90	16.63 d
S-$_x$	NS	NS	NS	NS	8.54
CV (%)	3.70	6.77	5.85	18.18	10.40

Mean having same or without letter (s) do not differ significantly at 5% level of probability.

4.2.2 Total dry matter (TDM) plant^{-1}

There were no significant variations among varieties in terms of total dry matter, but fertilizer treatments significantly affected total dry matter (Table 2) . Highest dry matter (48.55 g) was noted from USG basal dose (T_2) which was statistically similar to (45.69 g) prilled urea application (T_1) and the lowest (28.56 g) from USG at 25 DAS (T_4).

Total dry matter plant^{-1} was significantly influenced by the interaction between cultivars and nitrogen levels (Table 2). The highest total dry matter plant^{-1} was obtained from V_2T_2 (55.18 g) and it was statistically similar to V_2T_1 (50.21 g), V_1T_2 (49.93 g), V_1T_1 (45.48 g), V_2T_3 (45.03 g) and V_3T_1 (41.38 g) treatments. The lowest total dry matter plant^{-1} was obtained from treatment V_2T_4 (26.82 g), which was statistically similar to V_1T_4 (29.79 g) and V_3T_4 (29.06 g) treatments. These results were supported by Saikia *et al.* (2002) and Patil *et al.* (1997).They found that application of N increased the total dry weight of mustard plant.

4.3 Effect of different levels of nitrogen on yield and yield contributing characters of mustard

4.3.1 Number of siliqua plant^{-1}

Mustard cultivars showed a significant difference in producing the number of siliqua plant^{-1} (Table 2). Highest number of siliqua plant^{-1} (495.3) was produced by BARI Sarisha 11. The lowest number of siliqua plant^{-1}(114.5) was found in BARI Sarisha 14 and it was statistically similar to BARI Sarisha 13 (179.9).

Application of nitrogen fertilizer treatments significantly influenced the number of siliqua plant^{-1} (Table 2). Highest numbers of siliqua plant^{-1} (333.0) was obtained from the treatment USG basal dose (T_2), which was statistically similar to the treatment normal urea application (T_1) (305.1). The lowest number of

siliqua plant^{-1} (182.8) was obtained from USG at 25 DAS (T_4). Similar findings were reported by Deekshitula and Subbaiah (1997) and Bhagwan *et al*. (1996). They found that application of nitrogen increased the number of siliqua plant^{-1}of mustard.

The interaction between cultivars and nitrogen fertilizer had significant influence on the number of siliqua plant^{-1}. The highest numbers of siliqua plant^{-1} (654.7) was produced in BARI Sarisha 11 when USG was applied as basal dose (V_1T_2) and it was statistically identical with BARI Sarisha 11 treated with prilled urea (V_1T_1) and the lowest (96.57) was obtained from the treatment combination of V_3T_4 (Table 2).

4.3.2 Length of Siliqua (cm)

There was significant effect of cultivars on siliqua length (Table 2). The largest siliqua (6.66 cm) was produced in BARI Sarisha 13 (V_2) and the shortest (3.93 cm) in BARI Sarisha-11. However BARI Sarisha 11 and BARI Sarisha 14 gave statistically identical siliqua length.

Interaction effects between cultivars and nitrogen fertilizer on siliqua length was significant (Table 2). The longest siliqua was obtained from V_2T_1 (7.22 cm), which was statistically similar to V_2T_3 (6.80 cm) and V_2T_4 (6.52 cm) treatments. The shortest siliqua (3.60 cm) was noticed in V_1T_4 treatment.

4.3.3 Number of seeds siliqua^{-1}

Variation in number of seeds siliqua^{-1}across the varieties was significant which ranged from 11.06 to 30.93 (Table 2). Variety BARI Sarisha 13 (30.93) and BARI Sarisha 14 (30.22) produced highest number of seeds per siliqua. The lowest number of seeds siliqua^{-1} (11.06) was noted in BARI Sarisha 11.

There was significant effect of nitrogen fertilizer on number of seeds siliqua^{-1} (Table 2). Application of USG as basal dose produced the highest number of seeds per siliqua^{-1} (26.47) among the treatments. On the contrary, application of USG at 25 DAS produced lowest number of seeds siliqua^{-1} (21.47). The present results confirmed the report of Deekshitula and Subbaiah (1997). Sarandon *et al*. (1993) stated that the application of N-fertilizer yielded the higher number of seeds siliqua^{-1} in mustard.

Interaction between cultivars and N-fertilizer showed significant influence on the number of seeds siliqua^{-1} (Table 2). Significantly the highest number of seeds siliqua^{-1} was found in V_2T_2 (33.55) and V_3T_2 (33.37) treatments which was followed by to V_2T_1 (32.76) and the lowest was obtained from the treatment combination of V_1T_4 (10.10) and V_1T_3 (10.48) which was statistically similar to V_1T_1 (11.15) treatment.

4.3.4 1000 - Seed Weight

Significantl variation in 1000-seed weight was observed due to varieties (Table 2). Highest weight of 1000 seed was found in BARI Sarisha 11 (3.83 g) which was statistically identical with BARI Sarisha 13 (3.80 g). The lowest 1000-seed weight was noted from BARI Sarisha 14 (3.62 g). Thousand seed weight also showed significant difference due to variation on nitrogen management (Table 2).. The highest 1000-seed weight (3.92 g) was obtained from the plants treated with USG basal dose which was significantly different from all other treatments. Treatment T_1 and T_3 gave statistically identical 1000- seed weight The lowest one was recorded in the USG at 25 DAS (3.58 g). These results are in agreement with the findings of Deekshitula *et al*. (1997) in Indian mustard, Bhagwan *et al*. (1996), Patil *et al*. (1997) and Singh and Saron (1997) in mustard. They reported that 1000-seed weight in mustard increased with the application of nitrogen.

The interaction effect of cultivars and N fertilizer was not significant on 1000-seed weight (Table 2). The highest 1000 seed weight (4.10 g) was produced in V_2T_2 and it was not significantly different from V_1T_2 (3.89 g) and V_1T_1 (3.86 g) treatment. The lowest (3.38 g) was recorded in the treatment combination of V_3T_4.

Seed yield (t ha^{-1})

Seed yield ha^{-1} varied significantly among the varieties (Table 1).The highest seed yield ha^{-1} was recorded in BARI Sarisha 11 (1.76 t ha^{-1}) and it was significantly different from rest of the treatments.BARI Sarisha 13 (1.24 t ha^{-1}) and BARI Sarisha 14 (1.18 t ha^{-1}) produced statistically identical yield ha^{-1}. Applied nitrogen had the positive effect on seed yield ha^{-1} (Table 2). The highest seed yield (1.65 t ha^{-1}) was obtained from the plants treated with USG as basal. The lowest seed yield was obtained from USG at 25 DAS (1.17 t ha^{-1}) and it was statistically identical with USG at 15 DAS (1.28 t ha^{-1}).

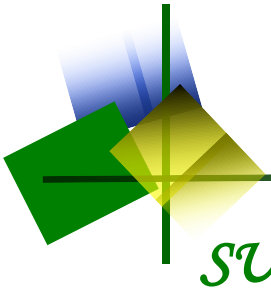
Varieties and N fertilizer interaction effects on seed yield ha^{-1} was statistically significant (Table 2). The highest seed yield ha^{-1} (2.06 t ha^{-1}) was obtained from BARI Sarisha 11 treated with USG basal dose (V_1T_2), which was statistically similar to BARI Sarisha 11(1.88 t ha^{-1}), treated with prilled urea treatment (V_1T_1).The lowest yield was noted from BARI Sarisha 14(0.98 t ha^{-1}) when USG was applied at 25 DAS (V_3T_4).

This shows the beneficial effect of N fertilizer as USG on development of seeds. Moreover, application of N fertilizer as USG with other nutrients in the soil helped maintaining soil fertility and observed favorable response that might have contributed to increase number of siliqua plant^{-1}, seeds siliqua^{-1}, and heavier seeds resulting higher yield.

Table 2: Main and combined effects of varieties and N-fertilizer treatments on no. of Siliqua plant^{-1}, length of Siliqua, total dry matter, no. of seeds per pod, 1000 seed weight and yield**(t ha^{-1})**

Treatments	**no. of Siliqua plant^{-1}**	**Length of Siliqua (cm)**	**Total Dry Matter (g)**	**no. of Seed pod^{-1}**	**1000 Seed Weight (g)**	**Yield (t ha^{-1})**
Variety						
BARI Sarisha 11(V_1)	495.3 a	3.925 b	40.23	11.06 b	3.827	1.760 a
BARI Sarisha 13(V_2)	179.9 b	6.660 a	44.31	30.93 a	3.800	1.241 b
BARI Sarisha 14(V_3)	114.5 b	4.487 b	35.92	30.22 a	3.618	1.179 b
S-$_x$	18.8	0.19	NS	0.33	NS	0.11
CV (%)	24.73	13.27	46.66	4.69	4.13	27.59
Fertilizer level						
Normal Urea (T_1)	305.1 a	5.248	45.69 a	24.72 b	3.771 b	1.475 b
USG Basal (T_2)	333.0 a	5.198	48.55 a	26.47 a	3.917 a	1.649 a
USG 15 DAS(T_3)	232.0 b	4.943	37.82 b	23.61 c	3.728 b	1.281 c
USG 25 DAS(T_4)	182.8 c	4.707	28.56 c	21.47 d	3.579 c	1.170 c
S-$_x$	14.58	NS	2.48	0.31	0.05	0.04
CV (%)	16.62	15.09	18.54	3.92	3.71	8.99
Combined of Variety and Fertilizer treatment						
V_1T_1	617.8 a	3.900	45.48	11.15 gh	3.857	1.884
V_1T_2	654.7 a	4.413	49.93	12.49 g	3.890	2.060
V_1T_3	409.5 b	3.799	35.72	10.48 h	3.820	1.610
V_1T_4	299.2 c	3.589	29.79	10.10 h	3.743	1.487
V_2T_1	178.5 de	7.216	50.21	32.76 ab	3.780	1.280
V_2T_2	216.9 d	6.107	55.18	33.55 a	4.100	1.523
V_2T_3	171.7 de	6.796	45.03	31.35 bc	3.713	1.120
V_2T_4	152.5 de	6.520	26.82	26.07 f	3.607	1.042
V_3T_1	118.9 e	4.627	41.38	30.27 cd	3.677	1.260
V_3T_2	127.6 e	5.075	40.55	33.37 a	3.760	1.363
V_3T_3	114.9 e	4.233	32.70	29.01 de	3.650	1.113
V_3T_4	96.57 e	4.013	29.06	28.24 e	3.387	0.9797
S-$_x$	25.25	NS	NS	0.54	NS	NS
CV(%)	16.62	15.09	18.54	3.92	3.71	8.99

Mean having same or without letter (s) do not differ at 5% level of probability.



CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the research field of the Department of Agronomy, Sher-e Bangla Agricultural University, Dhaka, during the period from 6 November 2009 to 10 February 2010 with a view to assess the comparative advantages of using urea super granule (USG) over Prilled urea on growth, yield and yield attributes of three mustard cultivars BARI Sarisha-11 and BARI Sarisha-13 and BARI Sarisha-14.

Data on growth and yield characters were recorded at vegetative stage and at maturity stage. The results showed that nitrogen had great influence on the morphological characters. The highest values of plant height (117.2 cm), number of primary branches (6.36) secondary branches (12.27) and number of leaves per plant (14.32) was obtained from the application USG as basal dose and the lowest of them was observed in USG at 25 DAS. The tallest plant (142.4 cm) was found in BARI Sarisha-11 than other two varieties and highest number of leaves was obtained from BARI Sarisha 14 (13.94) and BARI Sarisha 11 (13.44). Tallest plant number of leaves plant^{-1}, number of primary and secondary branch and leaf area was found in V_1T_2 V_3T_2 V_3T_2 V_1T_2 and V_1T_2, treatments.

Different levels of nitrogen had also significant effect on yield and yield components. The highest number of siliqua plant^{-1} (333.0), number of seeds siliqua^{-1} (26.47), 1000-seed weight (3.92 g), seed yield (1.65 t ha^{-1}) was found by the USG application as basal dose and the lowest yield and yield contributing characters of mustard was found in USG at 25 DAS.

Varietal performance on different yield attributes and yiedl varied significantly. BARI Sarisha 13 (V_2) produced the highest number of siliqua plant^{-1} (6.67 cm), number of seed siliqua^{-1} (30.93). BARI Sarisha 11 gave highest number of siliqua (495.3) plant^{-1} and yield (1.76 t ha^{-1}) among the varieties.

The interaction effects between nitrogen levels and cultivars had significant effect on number of siliqua plant^{-1}, siliqua length, number of seeds siliqua^{-1} 1000-seed weight, total dry matter and yield ha^{-1}. Highest total dry weight (55.18 g), number of seeds siliqua^{-1} (33.55) and 1000-seed weight (4.10 g) was found in BARI Sarisha 13 when USG was applied as basal dose. But highest number (654.7) of siliqua plant^{-1} and yield (2.06 t ha^{-1}) was obtained in BARI Sarisha 11 with USG basal dose.

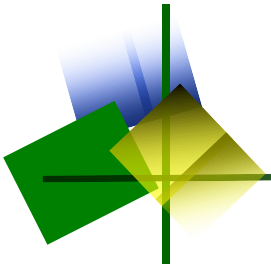
From the above results and discussions of the experiment, it could be concluded that-

(i) Application of nitrogen fertilizer in different forms and time influenced the growth and yield of mustard and BARI Sarisha 11 treated with USG as basal dose gave the best performance on growth and yield (2.06 tha^{-1}).

(ii) Mustard varieties positively responded to the application of USG

(iii) USG reduces 40% use of urea which lowers 20% of total cost in mustard production.

Further investigations may be done in different places of Bangladesh to find out the efficiency of USG in different crops with more treatment and design.



CHAPTER 6

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APPENDICES

APPENDICS 1

CHARACTERISTICS	VALUE
Ph	5.70
Organic matter(%)	2.35
Total N	0.12
K(me/100gm soil)	0.17
P (me/100gm soil)	8.90
S (me/100gm soil)	30.55
B (me/100gm soil)	0.62
Fe(me/100gm soil)	310.40
Zn(me/100gm soil)	4.82

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

APPENDICS 2

Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
November	26.98	14.88	71.15	00
December	25.78	14.21	68.30	00
January	25.00	13.46	69.53	10
February	29.50	18.49	50.31	00
March	33.80	20.28	44.95	8

Source: Bangladesh Meteorological department (climate and weather division), Agargaon, Dhaka

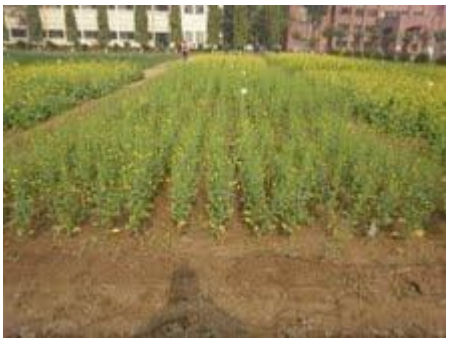
BARI Sarisha -11+ Normal Urea application

BARI Sarisha -14+ USG basal dose

BARI Sarisha -13+ USG at 15 DAS application

BARI Sarisha -13 + USG basal

BARI Sarisha -11 + USG basal



BARI Sarisha -11 + USG at 25 DAS

Plate 1. Photograph Showing the different interaction effect

BARI Sarisha -11 + USG at 15 DAS

BARI Sarisha -14 + Normal Urea application

BARI Sarisha -13 + Normal Urea application

BARI Sarisha -13 + USG at 15 DAS application

Plate 1(Cont.). Photograph Showing the different interaction effect

ANOVA

1. Plant height

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	1.461	0.731	0.0554	
Variety	2	21323.935	10661.967	809.1172	0.0000
Error	4	52.709	13.177		
Nitrogen	3	861.766	287.255	17.2459	0.0000
Variety×Nitrogen	6	262.990	43.832	2.6315	0.0519
Error	18	299.817	16.656		
Total	35	22802.677			

2. Number of Leaf Plant^{-1}

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	3.042	1.521	0.1182	
Variety	2	132.352	66.176	5.1429	0.0784
Error	4	51.470	12.867		
Nitrogen	3	58.338	19.446	27.8343	0.0000
Variety×Nitrogen	6	4.956	0.826	1.1824	0.3590
Error	18	12.575	0.699		
Total	35	262.733			

3. Primary Branches plant^{-1}

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	1.507	0.754	0.1557	
Variety	2	18.784	9.392	1.9410	0.2575
Error	4	19.356	4.839		
Nitrogen	3	8.488	2.829	25.7491	0.0000
Variety×Nitrogen	6	1.588	0.265	2.4093	0.0692
Error	18	1.978	0.110		
Total	35	51.701			

4. Secondary Branches plant^{-1}

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	12.619	6.310	0.1355	
Variety	2	127.856	63.928	1.3727	0.3516
Error	4	186.283	46.571		
Nitrogen	3	156.662	52.221	16.6123	0.0000
Variety×Nitrogen	6	41.145	6.857	2.1815	0.0933
Error	18	56.583	3.143		
Total	35	581.147			

5. Leaf Area plant^{-1}

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	3599.511	1799.756	0.7507	
Variety	2	262829.765	131414.882	54.8174	0.0012
Error	4	9589.284	2397.321		
Nitrogen	3	42472.075	14157.358	64.5746	0.0000
Variety×Nitrogen	6	16690.667	2781.778	12.6882	0.0000
Error	18	3946.329	219.240		
Total	35	339127.631			

6. Siliqua plant^{-1}

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	9077.846	4538.923	1.0705	0.4243
Variety	2	995061.330	497530.665	117.3376	0.0003
Error	4	16960.652	4240.163		
Nitrogen	3	126623.036	42207.679	22.0589	0.0000
Variety×Nitrogen	6	140071.023	23345.171	12.2008	0.0000
Error	18	34441.364	1913.409		
Total	35	1322235.251			

7. Length of Siliqua

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	0.514	0.257	0.5752	
Variety	2	50.056	25.028	55.9865	0.0012
Error	4	1.788	0.447		
Nitrogen	3	1.686	0.562	0.9776	
Variety×Nitrogen	6	3.342	0.557	0.9688	
Error	18	10.348	0.575		
Total	35	67.734			

8. Total Dry Matter

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	407.312	203.656	0.5800	
Variety	2	421.949	210.975	0.6009	
Error	4	1404.467	351.117		
Nitrogen	3	2169.476	723.159	13.0494	0.0001
Variety×Nitrogen	6	286.863	47.811	0.8627	
Error	18	997.506	55.417		
Total	35	5687.573			

9. Siliqua plant^{-1}

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	3.769	1.884	1.4770	0.3309
Variety	2	3051.788	1525.894	1196.0503	0.0000
Error	4	5.103	1.276		
Nitrogen	3	118.512	39.504	44.4085	0.0000
Variety×Nitrogen	6	39.458	6.576	7.3927	0.0004
Error	18	16.012	0.890		
Total	35	3234.641			

10. Yield

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	0.098	0.049	0.3328	
Variety	2	2.442	1.221	8.2543	0.0380
Error	4	0.592	0.148		
Nitrogen	3	1.211	0.404	25.6930	0.0000
Variety×Nitrogen	6	0.056	0.009	0.5953	
Error	18	0.283	0.016		
Total	35	4.682			

11. 1000-Seed Weight

ANOVA

Source	df	ss	MS	F	Prob.
Replication	2	0.016	0.008	0.3372	
Variety	2	0.310	0.155	6.4922	0.0555
Error	4	0.096	0.024		
Nitrogen	3	0.522	0.174	9.0090	0.0007
Variety×Nitrogen	6	0.154	0.026	1.3300	0.2947
Error	18	0.348	0.019		
Total	35	1.445			