EFFECT OF NITROGEN LEVELS AND NUMBER OF WEEDING ON THE YIELD, YIELD ATTRIBUTES AND QUALITY OF RAPESEED

BY

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REGISTRATION NO. 22899/00112

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGRONOMY

SEMESTER: JANUARY-JUNE, 2006

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CERTIFICATE

This is to certify that the thesis entitled "*Effect of nitrogen levels and number of weeding on the yield, yield attributes and quality of rapeseed*" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, 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 Roshni Rashid, Roll No. 00112, Registration No. 22899/00112 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 been duly acknowledged by her.

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Dated: June 2006
Place: Dhaka, Bangladesh

ACKNOWLEDGEMENT

At the outset, the author would like to express her deepest and heartfelt greatness to Almighty Allah who enabled her to pursue her education in Agricultural Science and to submit the thesis for the degree of M. S. in Agronomy.

The author wishes to express her heartfelt indebtedness, deepest sense of gratitude, sincere appreciation and profound respect to her research supervisor Dr. Md. Fazlul Karim, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his ingenious, invaluable and scholastic supervision, enthusiastic assistance, productive discussion, constructive criticism, constant encouragement and cordial help to all phases of study, research and preparation of this thesis.

The author also extends her deepest thanks and profound gratitude to Co-supervisor Dr. Md. Hazrat Ali, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his sincere co-operation and valuable suggestions for improving the manuscript.

The author wishes to express her gratefulness and indebtedness to Dr. Parimal Kanti Biswas, Chairman, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his sympathetic consideration, co-operation and valuable suggestions during the study period.

The author expresses cordial thanks to Mirza Hasanuzzaman, Lecturer, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his cordial help regarding experimentation, data analyses and writing up of this thesis.

The author extends her cordial thanks to all the respective teachers and staffs of the Department of Agronomy as well as Farm Super with others personnel of the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka due to their dutiful cooperation.

DEDICATED

TO

MY BELOVED PARENTS

The author is very much grateful to her parents, husband, brother and friends whose continuous love, sacrifice, efforts and inspiration helped her in completing the study successfully.

May Allah help and protect them all.

June 2006 **The Author**

ABBREVIATIONS AND UNITS

Abbreviation

AEZ	Agro Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
C.V.	Coefficient of Variation
cv.	Cultivar
DAS	Days after sowing
E	East
et al.	*et alibi* (and others)
etc.	*et cetra* (and so on)
FAO	Food and Agricultural Organization
Fig.	Figure
HI	Harvest index
HYV	High yielding variety
i:e.	id est (that is)
LSD	Least significant difference
N	North, Nitrogen
SAU	Sher-e-Bangla Agricultural University
viz.	Videlicet (namely)

Unit

%	Percentage
^{0}C	Degree Celsius
cm	Centimeter
g	Gram
ha	Hectare
kg	Kilogram
m	Meter
t	Ton

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ABSTRACT

A field experiment was conducted in the Rabi season (November-February) of 2005-2006 to study the response of rapeseed line SAU-C-F_7 in respect of yield, yield attributes and oil yield to different nitrogen levels and number of weeding. The treatment comprised of 4 levels of nitrogen and 3 levels of weeding. Different N levels were 0 kg N ha^{-1} (N_0), 90 kg N ha^{-1} (N_1), 120 kg N ha^{-1} (N_2) and 150 kg N ha^{-1} (N_3). The weeding treatments were no weeding (W_0), one weeding at 20 DAS (W_1) and two weedings at 20 and 45 DAS (W_2). The experiment was laid out in a factorial Randomized Complete Block Design (RCBD) with three replications. Nitrogen levels and number of weeding significantly influenced the growth, yield and yield attributes of rapeseed. Plants m^{-2}, plant height, branches $plant^{-1}$, siliquae $plant^{-1}$, length of siliqua, seeds $siliqua^{-1}$, 1000-seed weight, seed yield, stover yield, biological yield, harvest index, oil content and oil yield were significantly influenced by nitrogen levels and weeding as individual factor. Oil content was only influenced by nitrogen application. The results revealed that nitrogen at the rate of 120 kg ha^{-1} showed the best performance regarding to yield components and yields. The maximum seed yield ha^{-1} (2343.4 kg ha^{-1}) with 120 kg N ha^{-1} was 194.28%, 71.11% and 6.87% higher than the yield obtained from 0 kg, 90 kg and 150 kg N ha^{-1}, respectively. In case of weeding factor, it was observed that two hand weeding resulted in maximum production of yield and yield attributes as well as seed and oil yields. Two hand weeding increased the seed yield by 17.66% over control. The interaction effect of nitrogen levels and number of weeding revealed that 120 kg N along with two hand weeding showed the best performance in producing the yield attributes and yields. Number of branches $plant^{-1}$, number of siliqua $plant^{-1}$, number of seeds $plant^{-1}$, 1000-seed weight had a significant correlation with seed yield $plant^{-1}$ with the r values of 0.91, 0.97, 0.88 and 0.96, respectively. All of the yield attributes were highly significant. The relationship between the yield attributes and yield was highly significant.

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CHAPTER I

INTRODUCTION

Rapeseed-mustard belonging to the family Cruciferae is one of the important oil seed crop and currently ranked as the world's third important oil crop in terms of production and area. Worldwide the total annual production of *Brassica* is 44.41 million tons of seed from an area of 27.24 million hectares (FAO, 2004).

Rapeseed (*Brassica campestris* L.) is the principal oil crop of Bangladesh. Domestic production of edible oil almost entirely comes from rapeseed and mustard. The annual oil seed production is 376000 metric ton of which rapeseed covers 62% of the total edible oil (MOA, 2006). It is in the top of the list in respect of area and production compared to the oilseed crops cultivated in this country.

Rapeseed oil is widely used as cooking oil and medicinal ingredient and it supplies fat in our daily diet. Rapeseed oilcake is used as feed for cattle, fish and also as good manure for crops.

The average yield of rapeseed in Bangladesh is very low (0.73 t ha^{-1}) that is less than 50% of the world average (FAO, 2003). Bangladesh is running with acute shortage of 70% edible oil. Annually Bangladesh is producing about 0.16 million tons of edible oil against the requirement of 0.5 million tons. So, the country has to import oil and oilseeds at a cost of US $ 160 million every year (Wahhab *et al*., 2002). The major rapeseed-mustard growing areas in bangladesh has been given in Appendix I.

Oilseed crops have been shifted from main land to marginal land as wheat and potato growing areas are increasing. The oilseed production is decreasing with time. The demand of edible oil should be increased considerably to fulfill the demand.

A major reason of the low yield of rapeseed may be due to lack of HYV and proper management in cultivation systems. The yield of rapeseed can be augmented with the use of high yielding varieties and appropriate agronomic management. Fertilizer is the most important input to boost up the production of oilseed crops. Fertilizer is the depending source of nutrient, that can be used to boost up growth and yield of mustard (Islam *et al.*, 1992; Zhao *et al.*, 1997).

The optimum rate of nitrogen application play an important role in increasing the seed and oil yield through optimum nutrient uptake and utilization (Guitard, 1967 and Kalra, 1971). Rapeseed-mustard takes up most of the nutrients from the soil during the period of vegetative growth to flowering. Rapeseed-mustard has high requirements of nitrogen to give higher seed yield. Street *et al.* (1982) reported that an application of 135 kg N ha^{-1} produced maximum seed yield under irrigated conditions of Bangladesh. Rapeseed is highly responsive to nitrogen and it has tremendous influence on growth, dry matter production and seed yield (Gupta *et al.*, 1972; Ali and Rahman, 1986; Sharma, 1994; Misra and Rana, 1996; Thakuria and Gogai, 1996; Srinivas and Raju, 1997; Islam *et al.*, 2004). An optimum dose of nitrogen also increase the oil content and oil yield (Rahman, 1977; Roy *et al.*, 1981, Singh and Meena, 2003).

Yield of rapeseed is also hampered by different pests. Among them weed is an important factor in reducing yield. Weeds affect the plant growth, yield and quality of rapeseed. *Brassica* oil crops are sensitive to weeds competition, particularly in the early stages of growth. It was observed that if weed was not properly controlled the yield reduced by 46% as well as quality (Dixit and Gautam, 1996). Two hand weeding or mechanical weeding at 25 and 40 days after seeding (DAS) resulted in higher yield compared to that of weed infested plots i.e. control (Kaul and Das, 1986). *Brassica* oil crops are sensitive to weed, particularly in the early stages of growth. Therefore, weed control is very important for this crop in Bangladesh condition.

Hence, the present study was undertaken to study the response of rapeseed c.v. SAU Sarisha-1 to optimum levels of nitrogen and number of weedings with the following objectives:

(i) to find out the optimum level of nitrogen for the maximum production of yield and yield attributes of rapeseed.

(ii) to determine the number of weeding for optimum yield and yield attributes of rapeseed c.v. SAU Sarisha-1.

(iii) to study the combined effect of nitrogen and number of weeding on the yield, oil content and oil yield of rapeseed.

Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

Rapeseed is an important oil crop in Bangladesh which can contribute to a large extent in the national economy. But the research works done on this crop with respect to agronomic practices are inadequate. Only some limited studies have so far been done in respect of agronomic management practices like nitrogen level and weeding of the crop. Nevertheless, a number of such studies have been carried out in other parts of the world. Moreover, the information regarding to the interaction effect of the nitrogen levels and number of weeding are unavailable. However, some the studies relevant to the present piece of work have been reviewed following the parameters of plant growth and yield.

2.1 Effect of Nitrogen

2.1.1 Number of plants per m^2

Murtaza and Paul (1989) carried out a study with three cultivars of rapeseed viz. Pola, Tori-7 and Sampad grown under four levels of nitrogen fertilizer, urea (0, 50, 100, 200 kg ha^{-1}). Nitrogen levels varied the number of plants per m^2.

2.1.2 Plant height

Ali *et al.* (1976) noted in an experiment that nitrogen had significant effect on the plant height of mustard. The maximum height of plant was obtained at the rate of 78.46 kg N ha^{-1}.

Bhan and Singh (1976) reported that when *Brassica juncea* was provided with 120 kg N ha^{-1} remarkably increased the plant height.

Mondal and Gaffar (1983) observed that highest plant height of mustard variety 'Sampad' obtained with 140 kg N ha^{-1}, which was identical to that of 105 kg N ha^{-1}.

Singh and Saran (1987) set an experiment with *Brassica campestris* var. Toria at different doses of nitrogen. They found that nitrogen at the rate of 60 kg ha^{-1} increased plant height.

Shamsuddin *et al.* (1987) worked with mustard under five levels of nitrogen (0, 30. 60, 90 and 120 kg N ha^{-1}) and observed that plant height increased progressively with increasing levels of nitrogen but was not significantly different due to different levels of nitrogen. Nitrogen at the rate of 120 kg ha $^{-1}$ gave the tallest plant. Ali and Rahman (1986) reported maximum plant height at 120 kg N ha^{-1} while he applied different doses of nitrogen on rapeseed.

Islam and Mondal (1997) obtained maximum plant height of 93.6 cm at 300 kg N ha^{-1} while they applied 0, 100, 200 and 300 kg N ha^{-1} on mustard.

BARI (1999) investigated to identify the effect of nitrogen levels viz. 0, 80, 120 and 150 kg ha^{-1} on plant height of mustard. The plant height was 48.6, 63.8 and 77 cm following 0, 80, 120 kg ha^{-1}, as treatment variables.

BARI (1999) also conducted two trials in two different stations of Joydebpur and Iswardi of Bangladesh to justify the level of N_2 on the performance of mustard. The levels of nitrogen were 0, 120, 160 kg ha^{-1} and plant height was found 87.78, 113.94, 106.46 cm, respectively in Joydebpur and 90.79, 118.46, 113.69 cm in Ishwardi. The highest plant height was found in both the places at 120 kg N ha^{-1}.

2.1.3 Number of branches per plant

Ali *et al.* (1976) noted in an experiment that nitrogen had significant effect on the yield and yield contributing characters of mustard. The highest number of primary branches were obtained at 78.46 kg N ha^{-1}.

Shamsuddin *et al.* (1987) worked with mustard under five levels of nitrogen (0, 30. 60, 90 and 120 kg N ha^{-1}) and observed increasing plant height with increasing levels of nitrogen application but did not differ significantly with different levels. Nitrogen at the rate of 120 kg ha^{-1} gave the highest number of primary branches $plant^{-1}$ (5.30).

Murtaza and Paul (1989) studied three cultivars of rapeseed viz. Pola, Tori-7 and Sampad grown under four levels of nitrogen fertilizer, urea (0, 50, 100, 200 kg ha^{-1}). They reported that nitrogen had significant effect on number of primary branches $plant^{-1}$.

Tarafder and Mondal (1990) carried out an experiment to determine the effect of nitrogen on seed yield of mustard (var. Sonali Sarisha) following application of different doses of fertilizer and found that the number of branches per plant increased with increasing levels of nitrogen.

Sharma and Jain (2002) conducted an experiment with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) in a cropping system and observed that 80 kg N ha^{-1} resulted the highest number of branches $plant^{-1}$ (24.4).

Singh *et al.* (2002) reported that primary and secondary branches per plant increased significantly with the increase in nitrogen levels up to 120 kg ha^{-1}.

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard (*Brassica juncea*). They found that the highest number of branches per plant was obtained with the application of 120 kg N ha^{-1}.

Singh *et al.* (2003) reported the effect of row spacing (30, 45 and 60 cm) and nitrogen rates (60, 120 and 180 kg ha^{-1}) and basis of N application (row and even application) on the performance of indian mustard cv. Basanti. They observed that N at 120 kg ha^{-1}. produced higher number of branches per plant compared to 60 kg N ha^{-1}. The N level higher than 120 kg ha^{-1} did not increase the number of branches per plant.

2.1.4 Number of siliquae per plant

Scarisbrick and Daniels (1980) observed that the number of siliquae plant^{-1} in rapeseed increased significantly at both 100 kg ha^{-1} and 200 kg N ha^{-1}, compared with the control.

Singh and Saran (1987) set an experiment with *Brassica campestris* var. Toria at different doses of nitrogen. They have found that nitrogen at the rate of 60 kg ha^{-1} increased number of siliqua plant^{-1}.

Murtaza and Paul (1989) studied three cultivars of rape seed viz. Pola, Tori-7 and Sampad grown under four levels of nitrogen fertilizer, urea (0, 50, 100, 200 kg ha^{-1}). Nitrogen had significant effect on the production of siliqua plant^{-1}.

Janzen (1990) observed 1974.0, 2936.6, 3315.1 and 5023.8 siliquae m^{-2}, respectively while applying 0, 50, 100, 200 kg ha^{-1} in rapeseed.

Sharma (1994) found the number of siliqua m^{-2} of rapeseed as 2681.7, 4864.1, 5189.2, and 4318.4, respectively following application of 4 levels of nitrogen (0, 100, 200, 300 kg ha^{-1}).

Rahman (1994) applied nitrogen at the rate of 0, 120, 160 kg ha^{-1} on rapeseed and number of siliquae $plant^{-1}$ was found 30, 58, and 63 respectively.

Islam and Mondal (1997) conducted an experiment with four level of N (0, 100, 200, 300 kg ha^{-1}) and found 57.21, 71.04, 125.00, 87.40 siliquae $plant^{-1}$, respectively in mustard.

BARI (1999) investigated a field trial with application of 4 levels of N (0, 80, 120, 140 kg ha^{-1}) on mustard. No. of siliquae per plant was found 22.7, 42.0, 45.6, 48.0, respectively

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

Sharma and Jain (2002) studied with application of five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) in mustard in a cropping system. They reported that the application of 80 kg N ha^{-1} resulted in the highest number of siliquae per plant.

Singh *et al.* (2002) reported that siliquae per plant of rapeseed increased significantly with the successive increase in nitrogen up to 120 kg ha^{-1}.

Shukla *et al.* (2002) performed an experiment to observe the effect of integrated nutrient management in Indian mustard (*Brassica juncea*). They found maximum number of siliquae per plant with the application of 120 kg N ha^{-1}.

2.1.5 Length of siliqua

Sen *et al.* (1977) found that the siliqua length was increased significantly by the application of increased levels of N to *Brassica juncea.*

Singh (2002) conducted an experiment with Varuna variety of mustard having 5 levels of nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and five levels of P (0, 15, 30, 45 and 60 kg ha^{-1}). Application of N and P increased the length of siliqua. However, the significant increase in length of siliqua was recorded in 60, 90 and 120 kg N ha^{-1} and 30, 45 and 60 kg P ha^{-1}.

Singh *et al.* (2002) also reported that growth characters and length of siliqua increased significantly with the successive increase of nitrogen up to 120 kg ha^{-1}.

2.1.6 Number of seeds per siliqua

Scarisbrick and Daniels (1980) observed that number of seeds per siliqua were not affected from 0 to 200 kg N ha^{-1}.

Murtaza and Paul (1989) studied three cultivars of rapeseed viz. Pola, Tori-7 and Sampad grown under four levels of nitrogen fertilizer, urea (0, 50, 100, 200 kg ha^{-1}). Nitrogen had significant effect on the production of number of seeds $siliqua^{-1}$.

Tarafder and Mondal (1990) conducted an experiment to study the effect of nitrogen on rapeseed (var. Sonali Sharisa) and found that nitrogen fertilizers increased the number of seeds $siliqua^{-1}$.

Sharma and Jain (2002) conducted an experiment with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) on mustard in a cropping system and found that the application of 80 kg N ha^{-1} resulted in the highest number seeds per siliqua (15.3).

2.1.7 1000 seed weight

Scarisbrick and Daniels (1980) observed that the seed weight were not affected from 0 to 200 kg ha^{-1} of nitrogen application.

Singh and Saran (1987) set an experiment with *Brassica campestris* var. Toria and different doses of nitrogen. They found that nitrogen at the rate of 60 kg ha^{-1} increased 1000-seed weight.

Shamsuddin *et al.* (1987) studied mustard with five levels of nitrogen (0, 30. 60, 90 and 120 kg N ha^{-1}) and observed that nitrogen influenced 1000 seed weight significantly.

Minni (1990) reported 1000 seed weight were 2.12, 2.14 and 2.16 g, respectively due to spraying of 0.0, 5.0, 7.5% N. Rahman (1991) observed 2.00, 2.08, 2.13 g 1000-seed weight, respectively with 0, 120, 160 kg N ha^{-1} on rapeseed.

Omar (1991) reported 3.03, 3.04 and 3.00 g of 1000-seed weight, respectively following application of 40, 60, 80 kg ha^{-1}.

Battman (1992) conducted an experiment in winter canola (*Brassica napus*) applying 0, 40, 80 kg N ha^{-1} in field condition. Weight of 1000 seed was remained unaffected with the different levels of nitrogen.

Mondal *et al.* (1996) conducted an experiment on mustard with nitrogen at the rate of 0, 100, 200, 300kg ha^{-1}. They observed weight of 1000 seed increased up to 200 kg N ha^{-1}. Islam and Mondal (1997) observed 2.23, 2.22, 2.19 and 2.04 g 1000-seed weight, respectively following application of 4 levels of nitrogen (0, 50, 100, 200 kg ha^{-1}).

Sharawat *et al.* (1998) observed that application of nitrogen at the rate of 0,120, 160 kg ha^{-1} on rapeseed produced 2.0, 2.08, 2.13 g of 1000 seed weight, respectively.

2.1.8 Seed yield per plant

Ali *et al.* (1976) noted in an experiment that nitrogen had significant effect on the yield and yield contributing characters of mustard. The maximum weight of seed plant^{-1} was obtained highest at the rate of 78.46 kg N ha^{-1}.

Murtaza and Paul (1989) studied three cultivars of rape seed viz. Pola, Tori-7 and Sampad under four levels of nitrogen fertilizer, urea (0, 50, 100, 200 kg ha^{-1}) and found that nitrogen had significant effect on seed yield plant^{-1}.

2.1.9 Seed yield per hectare

Agarwal and Gupta (1977) applied four levels of nitrogen viz. 0, 25, 50 and 75 kg ha^{-1} to *Brassica campestris* var. Tori grown on a sandy loam soil under irrigated conditions and found that seed yield increased by 35% with the application of 50 kg N ha^{-1} over control.

Gupta and Das (1978) concluded that the optimum oconomic rates of nitrogen application for maximum yield to *Brassica campestris* var. yellow sarsan in Uttar Predesh was 165 kg N ha^{-1}. Singh *et al.* (1978) found that the application of N at 60 and 90 kg ha^{-1} to mustard variety 'T-59' resulted significantly more seed yield than the control. They also observed that more seed yields were obtained with 60 kg N ha^{-1} over 30 kg N ha^{-1}. They also reported that seed yield increased from 1.2 to 1.4 t ha^{-1} with increasing nitrogen rate from 30 to 60 kg ha^{-1} in 1974.

Gangasaran and Kinra (1979) conducted an experiment where rai was given 0, 40, 80, 120 or 160 kg N ha^{-1}. The seed yield was highest (1.66 t ha^{-1}) with the application of 160 kg N ha^{-1}. They concluded that the economic rate of nitrogen application was 132 kg ha^{-1}.

Patel *et al.* (1980) performed a field experiment with four levels of nitrogen viz. (0, 25, 50 and 75 kg ha^{-1}). They reported that different levels of nitrogen gave significantly different seed yields of mustard significantly. The highest seed yield (0.73 t ha^{-1}) achieved at the rate of 50 kg N ha^{-1} due to the formation of higher number of secondary branches $plant^{-1}$, higher number of siliquae $plant^{-1}$and higher harvest index.

Narang and Singh (1985) fertilized Indian mustard with four levels of nitrogen (0, 50,100 and 150 kg ha^{-1}). They observed that nitrogen at the rate of 150 kg ha^{-1} gave the highest seed yield (1.8 t ha^{-1}).

Singh and Singh (1987) stated that increasing rate of nitrogen from 0 to 75 kg ha^{-1} applied to mustard (*Brassica juncea*) increased the seed yield from 1.20 -1.33 to 2.11-2.14 t ha^{-1}. Further increase in nitrogen rate (100 kg ha^{-1}) could not improve seed yield.

Singh and Saran (1987) set an experiment with *Brassica campestris* var. Toria and applied different doses of nitrogen. They found that nitrogen at the rate of 60 kg ha^{-1} increased the seed yield. This dose gave seed yield of 1.20 t ha^{-1} compared to 0.89 t ha^{-1} without nitrogen. A further increase in yield with 90 kg N ha^{-1} was not significant. Shamsuddin *et al.* (1987) worked with mustard with five levels of nitrogen (0, 30. 60, 90 and 120 kg N ha^{-1}) and observed that nitrogen at the rate of 120 kg ha^{-1} gave the highest seed yield (830 kg ha^{-1}). Singh and Rathi (1987) noticed that when N was applied at 120 kg ha^{-1}, the seed yield of mustard was increased substantially.

BARI (1989) conducted a series of fertilizer trials on mustard in the farmers field throughout the country. The dose of nitrogen were 43, 65, 87, and 109 kg ha^{-1}.

They reported that with increasing levels of fertilizers the yield of mustard increased progresively but 109 kg N gave the highest yield.

Tomar and Mishra (1991) observed seed yield *Brassica juncea* as 0.84, 0.69, and 0.60 t ha^{-1} with the application of same dose of nitrogen. Application 60 kg N ha^{-1} gave 35% more yield over control.

Nuttal and Moulin (1992) conducted an experiment and applied two level nitrogen 45 kg & 134 kg ha^{-1} on rapeseed and yield was found 1.39 t ha^{-1} and 1.50 t ha^{-1} respectively.

Letu *et al.* (1994) reported that application of 3 levels of N (0, 120, 160 kg ha^{-1}) gave 1.3, 1.4 and 1.5 t ha^{-1} respectively of seed yield. Wamuongo (1995) showed that application of N fertilizer when water supply was adequate promoted growth of all plant part and increased yield with favourable moisture condition. When nitrogen was not applied there was more conservation in use of available soil water leading to less dry matter product.

Islam and Mondal (1997) in a field trial showed that application of four levels of nitrogen (0, 100, 200, 300 kg ha^{-1}) gave seed yield of 0.69, 1.29, 1.45, 1.21 t ha^{-1}, respectively. They observed seed yield increased profitably up to 200 kg N ha^{-1}.

Hossain and Gaffer (1997) conducted a trial at Shyampur, Rajshahi with 5 level of nitrogen (0, 100, 150, 200, 250 kg ha^{-1}) on rapeseed and maximum yield was found 1.73 t ha^{-1} with 250 kg N ha^{-1}. Mondal *et al.* (1996) reported that application of 50% nitrogen at the time of final land preparation and the rest 50% nitrogen as top dressing at late vegetative or before flowering increased the yield of rapeseed variety SS-75.

Patel (1998) conducted an experiment to study the response of mustard (*Brassica juncea*) cv. Varuna to 4 levels of nitrogen (0, 20, 40 and 80 kg ha^{-1}). He obtained seed yield of 0.43, 0.73, 0.95 and 1.21 t ha^{-1} with 0, 20, 40 and 60 kg N ha^{-1}, respectively.

Singh *et al.* (1998) reported that seed yield values were increased with increasing nitrogen rates (0, 40, and 80 kg N ha^{-1}). Dobariya and Mehta (1995) also reported that increasing nitrogen rate from 25 to 75 kg ha^{-1} increased seed yield from 2.07 - 2.41 t ha^{-1}.

Zekaite (1999) reported that, the seed yield of rapeseed 0.88 t ha^{-1} was obtained at a nitrogen fertilization of 90 kg ha^{-1}. Fertilization of nitrogen at 120 kg ha^{-1} significantly increased the yield over that of 90 kg ha^{-1}.

BARI (1999) investigated mustard varieties with 4 levels of nitrogen 0, 80, 120, 140 kg ha^{-1} and yield was found 493.3, 833.3, 940.0 and 993.7 kg ha^{-1}, respectively. BARI (1999) also investigated fertilizer trial at Joydebpur & Ishurdi with 3 levels of nitrogen (0, 120,160 kg ha^{-1}) and yield was found at Joydebpur 389.89, 735.67, 910.67 kg ha^{-1}.& Ishurdi 559.11, 835.00, 1070.00 kg ha^{-1}, respectively.

Sidlauskas (2000) found that the yield of rapeseed was increased with the increasing rate of nitrogen levels up to 120 kg ha^{-1}. Further increase of nitrogen level did not affect the seed yield.

Ghosh *et al.* (2001) conducted an experiment to study the response of 3 levels of K (0, 12.5 and 25 kg ha^{-1}), 3 levels of N (0, 40 and 80 kg ha^{-1}) and biofertilizers (*Azotibacter, Azospirillum*) under irrigated condition. Interaction between K and biofertilizer and between biofertilizer and N were found significant in increasing the yield of rapeseed. They observed that maximum yield of rapeseed was obtained at 80 kg N ha^{-1} along with 12.5 kg K ha^{-1}.

2.1.10 Stover yield per hectare

Meena *et al.* (2002) conducted an experiment to study the effect of nitrogen, irrigation and intercultural operation on yield and yield attributes of mustard. The results of experiment revealed that the application of 60 kg N ha^{-1} registered significantly higher stover yield of mustard over control. Singh *et al.* (2002) also reported that stover yield increased significantly with the successive increase in nitrogen up to 120 kg ha^{-1}. Singh and Prasad (2003) also mentioned that 120 kg N ha^{-1} gave the highest stover yield (12.22 q ha^{-1}) of mustard.

2.1.11 Harvest Index

Shrivastava *et al.* (1988) observed in an experiment conducted with mustard (*Brassica juncea* cv. varuna) that the application of nitrogen at the rate of 90 kg ha^{-1} at the pre-flowering stage gave the highest harvest index.

Shukla and Kumar (1997) grew six varieties of Indian mustard to assess the effect of nitrogen fertilization on yield attributes, seed yield and oil content. They found that N application at the rate of 120 kg ha^{-1} significantly influenced the harvest index.

2.1.12 Oil content

Kolodzie and Debowska (1973) reported the effects of 60, 150 and 240 kg N ha^{-1} on the seed yield, oil content and fatty acid composition of winter rape. Results indicated that while seed yield increased, seed oil content decreased with increase in applied N. Oil composition was little affected though oleic and linolieic acid contents increased and that of Erucic acid deceased with increased rate of N.

Rahman (1977) reported that N alone in excess caused lodging, delayed maturity and decreased oil content and increased protein content in seed of *Brassica spp.* Henry and MacDonald (1978) showed that application of N increased the seed yield but decreased the oil content in seed.

Vir and Verma (1979) reported that the oil content in the seed of *Brassica juncea* decreasd due to increase of N from 0 to 60 kg ha^{-1}. Michael *et al.* (1979) also noticed that application of N from 0 to 270 kg ha^{-1} reduced the oil content, on an average, by about 2 percent in winter oil seed rape.

Aulakh *et al.* (1980) showed that in yellow sarson oil production increased by 12 percent with N at 60 kg ha^{-1}.

Roy *et al.* (1981) studied the growth and fertilizer response of Indian mustard cv. Varuna and observed that beyond 120 kg N ha^{-1}, the oil percent in seeds decreased with further increase in N.

Singh and Sharma (1982) observed 15.7 percent increase in oil yield with N level when supplemented with 200 mm initial soil moisture + 50 mm irrigation.

Singh and Rathi (1984) concluded from their study on *Brassica juncea* cv. Varuna that there was a linear increase in cake yield with increasing rate of N, while the reverse was true for oil content. It decreased oil content from 40.09 percent in control to 37.05 percent at 160 kg N ha^{-1}.

Sah *et al.* (1985) reported that the oil content of *Brassica campestris* decreased remarkably at different levels of N application. They further concluded that a minimum amount of S was needed for increase of seed and oil yields in mustard whether it was applied singly or in combination with N.

Narang and Singh (1985) observed that N affected the oil composition of *Brassica juncea.* Higher N rates increased protein content, allyl- isothiocyanate content and iodine value of the oil.

Singh and Saran (1987) reported that application of N from 0 to 90 kg ha^{-1} did not differ the oil content but significantly increased the protein content in the seed of Indian rape.

Singh and Rathi (1987) noticed that when N was applied at 120 kg ha^{-1} increased seed yield but percent oil in seed decreased from 40.41 to 37.12 by adding 0 to 120 kg N ha^{-1}.

Patil and Bhargava (1987) reported that increasing rates of N (0 to 120 kg ha^{-1}) significantly increased the N and protein contents and decreased oil content in seed.

Ibrahim *el al.* (1989) found from an experiment with different levels of N for the production of rapeseed, N rates did not differ the oil content and its fatty acids (Palmatic, Steric, Oleic, Linoleic, Arachidic and Erucic acid).

Rathore and Manohar (1989) noticed that application of N from 90 to 160 kg ha^{-1} increased oil yield of mustard (*Brassica juncea)* compared with low to zero N rate. They also reported that oil content did not differ against different N rates.

Dubey and Khan. (1991) carried out an experiment on *Brassica juncea* cv. Varuna and was given 0, 30, 60 or 90 kg N ha^{-1} under irrigated condition. Seed oil content decreased by N application.

Abadi *et al.* (2001) also indicated that N had a significant effect on oil content of rapeseed and mustard.

Shukla *et al.* (2002) investigated six varieties of Indian mustard (Krishna, Varuna, Vardan, Kranti, Rohini and Pusa Bold) to assess the effect of nitrogen fertilization on seed yield and oil content. A decreasing trend of oil content was observed with the increase in N fertilization.

Prasad *et al.* (2003) reported the effects of N, S and Zn fertilizers on nutrient uptake, quality and yield of Indian mustard (cv. Vaibhav).The application of 60 kg N ha^{-1} gave the highest oil content (39.98 %).

Singh and Meena (2003) conducted a field experiment to determine the effect of N fertilizers (20, 40, 60, 80 and 100 kg N ha^{-1}) on the oil and protein yield of Indian mustard cv. Varuna. Pooled analysis of data showed that 40 kg N ha^{-1} gave the highest oil content (39.61%). The most profitable rate of N was found at 80 kg ha^{-1}.

Meena and Sumeriya (2003) carried out a study to evaluate the effect of nitrogen (0, 30, 60 and 90 kg ha^{-1}) on oil content of mustard *Brassica juncea.* Application of.60 kg N ha^{-1} gave the maximum oil (37.04%) content, compared to no nitrogen application.

Singh *et al.* (2004) conducted an experiment to study the response of Indian mustard cv. T-59 to nitrogen and sulfur rates. Different levels of nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) application did not differed the oil content in mustard

2.1.13 Oil yield

Vidyapati *et al.* (1981) studied the yield of oil of Indian mustard (*Brassica juncea*) with different nitrogen dose and reported that the oil yield increased significantly up to 120 kg N ha^{-1}.

Gawai *et al.* (1994) conducted an experiment to assess the impact of 0-100 kg N ha^{-1} on the performance of mustard (*Brassica juncea*) cv. TM-17 and concluded that oil yield increased with N rate, reaching a plateau at 75 kg ha^{-1}.

2.2. Effect of Weeding

2.2.1 Weeds of mustard crop

Karim *et al.* (1994) reported most prominent weeds of mustard crops as *Cyperus rotundus, Cynodon dactylon, Paspalum scrobiculatum, Alternanthera sessilis* and *Panicum repens, Hygrophila polysperma, Plygonum plebejum, Eclipta alba, Digitaria sanguinalis, Leucus aspera*, and *Alternanthera philoxeroides*.

Ghosh *et al.* (1994) conducted an experiment on weed in mustard in sandy loam at Kharagpur, India during 1987-89. The most problematic weeds were *Digitaria sanguinalis, Echinochloa crus-galli, Cyperus rotundus. Cynodon dactylon, Croton sperciflora* and *Eclipta alba*.

Rujput *et al.* (1994) studied the weed control in mustard. They identified most problematic weeds were *Boerhavia diffusa, Cyperus rotundus, Chenopodiurn album, Trianthema monogana, Asphodelus tenuifolius, Melilotus indica* and *Convolvulus arvensis*.

Singh *et al.* (1994) observed that the most problematic weed species of mustard (*Brassica juncea* L. Czern and coss) were *Chenopodium album, Melilotus indica, Avena fatua* and *Phaseolis minor*.

2.2.2 Weed dry matter

Raghvani *et al.* (1985) studied on crop-weed competition in mungbean during kharif, from 1979-80 to 1982-83 on medium black soils of Junagadh in India. They observed that there was reduction in the dry weight of weeds with an increase in frequency of weeding. The recorded highest dry weight in control (no weeding) and lowest in weeding done thrice at 15, 30 and 45 DAS.

In Faizabad, India, Singh and Singh (1995) conducted trials during the winters of 1985-86 and 1986-87 on the effect of weed control on nutrition uptake by mustard and associated weeds. There were 4 weed control treatments (i.e. hand weeding once 25 days after sowing (DAS) hoeing 25 DAS + hand weeding 35 DAS, preem isoproturon at 0.75 kg ha^{-1} and preem, thiolencarb at 10 kg) on nutrient uptake by *Brassica juncea* cv. Karti and associated weeds. All weed control treatments decreased weed DM from untreated control.

2.2.3 Plant height

In an experiment, Gaffer (1984) observed that plant height of mustard was favourably increased with the spell of weed free periods by hand weeding.

2.2.4 Number of branches per plant

Chemale and Fleck (1984) conducted an experiment on soybean cultivars in competition with *Euphorbilie terophylla*. They observed that the number of branches was reduced after 75 days of crop-weed competition and two hand weeding gave the best results.

In an experiment, Gaffer (1984) observed that primary branches $plant^{-1}$ were favourably increased with the spell of weed free periods.

2.2.5 Number of siliquae per plant

Chemale and Fleck (1984) conducted an experiment on soybean cultivars in competition with *Euphorbilie terophylla*. They observed that the number of pods decreased with increasing weed density.

Yadav *et al.* (1984) observed that siliquae yields of rapeseed were significantly increased by removing weeds at 2, 4, 6 or 8 week after sowing (WAS). Further delay in weed removal had little effect on production of siliquae.

Gaffer (1984) pointed out that number of siliquae plant^{-1} of rapeseed were favourably increased with the spell of weed free periods.

Sarkar and Mondal (1985) noted that weeding of different dates affected some yield contributing characters and yield in different varieties of mungbean. One weeding gave maximum number of pod plant^{-1} and two weeding did identical result.

2.2.6 Number of seeds per siliquae

Chemale and Fleck (1984) conducted an experiment on soybean cultivars in competition with *Euphorbilie terophylla*. They observed that the number of seeds pod^{-1} decreased with increasing weed density.

Sarkar and Mondal (1985) observed that weeding at different dates affected some yield contributing characters and yield in different varieties of mungbean. One weeding gave maximum number of seeds pod^{-1} in Mubarik and two weding did identical result.

2.2.7 Seed yield

Roebuck and Trennery (1978) conducted an experiment on weed control in winter oilseed rape and observed that effective weed control in the autumn increased the total crop dry weight at the start of flowering by 80-90%.

Kondap *et al.* (1982) investigated on the competitive ability of certain crops against purple nutsedge (*Cyperus rotundus*) and observed that the grain yield of different crops under weed free and purple nutsedge weedy check treatments differed significantly. The competition from purple nutsedge caused yield reduction in maize (6.12%) followed by blackgram (23.45%) groundnut (31.72%) and soybean (57,85%).

Singh and Tripathi (1982) reported that weeding at an interval of 15 days followed by weedy condition caused a significant increase in yield over check.

In an excperiment Singh *et al.* (1983) found that uncontroled weeds reduced the yield of cauliflower species from 36.6 to 59.1%. Competion with weeds for first 15 days and beyond resulted in significant yield reduction. Competion after 60 DAT (Days after transplanting) had no adverse effect on yield.

Chemale and Fleck (1984) conducted an experiment on soybean cultivars in competition with *Euphorbilie terophylla*. They observed that soybean seed yield was reduced by weed competition.

In an experiment on weed Hakansson (1984) observed that yield loss per individual weed increased with the reduction in weed density and yield loss was directly related to weed weight.

Gaffer (1984) observed that the totally weed free condition produced the maximum seed yield and yield components of rapeseed. He also found that yield reduction was 23.0% in weedy plots (control) as compared to totally weed free plots.

Ambasht and Chakhaiyar (1984) observed the effect of weeding and weed free duration on the growth and yield of mustard (*Brassica juncea*). They found that the maximum reduction in seed yield due to weed occurred between 20 and 40 days of growth in mustard.

Sarkar and Mondal (1985) observed that weeding of different dates affected some yield contributing characters and yield in different varienties of mungbean. Grain yield was reduced by 49 to 55% when weeds were allowed to grow undisturbed.

BARI (1985), studied yield loss due to uncontrolled weed growth in upland crops. The lowest yield reduction for mustard cv. SS-75 was only 12.29%.

Raghvani *et al.* (1985) studied on crop-weed competition in mungbean during kharif, from 1979-80 to 1982-83 on medium black soils of Junagadh in India. Weed control during this period effected greater weed control efficiency and higher grain yield as also higher net monetary return. They concluded that delay in weeding resulted in reduction of crop yield.

Ciriciofolo and Bianchi (1985) carried out an experiment on cultivation technique of oilseed rape and observed that weed control is required to reduce weed competition at crop emergence and to avoid problems associated with harvest.

The competition effect of some weed species on the yield of winter oilseed rape was studied by Adoczewski (1990). In 7 years trials he observed that in oilseed rape at Winnagora, *Anthamis arvensis, Tripleurospermum inodorum* and Volunteer rye were the most competitive weed. He also found large infestations causing up to 50% yield decreases.

Bowerman (1990) studied for controlling weeds in winter oilseed rape and observed that significant yield increase were achieved mainly where the level of weed control was high.

Walker *et al.* (1990) evaluated yield response to seed control in oilseed rape in Scotland. They conductd in total of 16 oilseed rape trials during 1983-89 which resulated in an yield increase of 7%. They also noticed that there was no relationship between weed density and yield response.

Donovan and Sharma (1994) conducted an experiment on oilseed crops and factors associated with crop losses due to weeds. They found that the yield loss generally increased with increasing wild oat population. Crop quality was reduced due to weeds.

Ali (1994) studied crop weed competition in various crops including mustard. He conducted an experiment on sandy loam to study the nature and magnitude of crop weed competition in intercropped chickpeas-cv. Radhey/mustard cv. varuna (4:1 row ratio). The loss of seed yield caused by crop competition with weeds until the time of crop maturity was 34% in mustard.

In Cuba, an experiment was conducted by Fundora *et al.* (1994) on the effect of weed incidence on soybean productivity. They found that yield reduction occurred between 60% and 80% when plots were left with grass cover and these were independent of the length of the unweeded period. The presence of weeds in the last 30 days of the plant cycle favoured a general increase in fruit infection indices. They also concluded that weed control is necessary at 30 days of germination of plant particularly in seed production areas.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

A field experiment with different nitrogen levels and number of weeding was conducted in the winter season (Rabi), November-February, 2005-2006 to evaluate the response of rapeseed c.v. SAU Sarisha-1 in respect of yield, yield attributes and oil yield.

3.1. Experimental Site

The research was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental field is located at 90^0 335′ E longitude and 23^0 774′ N latitude at a height of 9 meter above the sea level (BCA, 2004). The land was medium high and well drained.

3.2. Climate

The annual precipitation and potential evapotranspiration of the site were 2152 mm and 1297 mm, respectively. The average maximum and minimum temperature was 30.34^{0}C and 21.21^{0}C, respectively with mean temperature of 25.17^{0}C.

Temperature during the cropping period ranged between 12.2^{0}C and 31.2^{0}C. The humidity varied from 73.52% to 81.2%. The day length ranged between 10.5 and 11.0 hours and there was no rainfall during the experimentation. The weekly average rainfall, air temperature and relative humidity of the site during the experimental work have been shown in Appendices II, III and IV.

3.3. Soil

The soil of the experimental site belongs to the agro-ecological region of "Madhupur Tract" (AEZ No. 28). It was Deep Red Brown Terrace soil and belonged to "Nodda" cultivated series. The top soil is silty clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.47 - 5.63.

3.4 Experimental materials

The experiment was done with an advanced line of rapeseed (*Brassica campestris*) c.v. SAU Sarisha-1 which was developed by Sher-e-Bangla Agricultural University, Dhaka-1207. The variety is high yielder and Erucic acid content is comparatively lower.

3.5. Experimental treatments

There were two factors in this experiment viz. N levels (N) and number of weeding (W) levels as alone or in combination. Different N levels were 0, 90, 120 and 150 kg N ha^{-1} and these were named as N_0, N_1, N_2 and N_3, respectively. The weeding treatments were no weeding (W_0), one weeding at 20 DAS (W_1) and two weeding at 20 and 45 DAS (W_2).

3.6 Experimental layout and design

The experiment was laid out in a Randomized Complete Block Design (RCBD) (Factorial) with three replications. The unit plot size was 3 m × 2 m = 6 m^2. The distance between two adjacent unit plots was 0.5 m and distance between two replications or between two blocks was 1.5 m.

3.7. Crop Husbandry

3.7.1. Land Preparation

The experimental field was ploughed with power tiller and rotovator. Subsequent cross ploughing was done followed by laddering to make the land level. All weeds, stubbles and residues were removed from the field.

3.7.2. Fertilization

The experimental plots were fertilized with a recommended dose of 90, 60, 65, 5 and 6 kg ha^{-1} of P_2O_5, K_2O, Sulphur, Zinc Oxide (ZnO) and Boron, respectively and Urea as per treatment. During final land preparation one half of the required amount of urea and total amount of all other fertilizers were applied and incorporated into soil. Rest of the urea was top dressed during first weeding at 25 DAS.

3.7.3. Sowing of seeds

Seeds of SAU-C-F_7 line were sown on 15th October, 2005 maintaining 30 cm row spacing in each plot. Sowing was done continuously in rows.

3.7.4. Weeding and thinning

The experimental plots were found to be infested with different kinds of weeds, viz. Bathua (*Chenopodium album* L.), Bermuda grass (*Cynodon dactylon*), Nut sedge (*Cyperus rotundus* L.), Biskatali (*Polygonum hydropiper* L.), Goose grass (*Eleusine indica*) etc. Weeding was done manually with 'nirani' following treatment variables. Thinning was done in all the unit plots with care to maintaining a constant plant population in each row. Finally plants were kept at 5 cm distance in rows.

3.7.5. Irrigation

First irrigation was given at 25 days after sowing (DAS) the second irrigation was given at 55 DAS with check basin method.

3.7.6. Pest and disease management

The crop was sprayed with Malathion 60 EC to prevent infestation of mustard aphids at siliquae formation stage. Dithane M-45 was applied to prevent soft rot of plants (*Sclerotium rolfsii*).

3.7. Harvesting and Processing

At maturity when 80% of the siliqua turned straw yellowish in colour, the experimental crop was harvested. Harvesting was done in the morning to avoid shattering. Four linear meters (1 m^2) were harvested from the centre of each plot at ground level with the help of a sickle. Prior to harvesting, ten plants were sampled randomly from each plot leaving the border lines and harvested area and uprooted for collection of different yield contributing characters data. The harvested plants from each plot were bundled separately, tagged and brought to a clean cemented threshing floor. The crop was sun dried properly by spreading them over the floor and seeds were separated from the siliqua by beating the bundles with the help of bamboo sticks.

The seeds thus collected were dried in the sun for reducing the moisture in the seed to about 9% level. The stovers were also dried in the sun. Seed and stover yield were recorded. The biological yield was calculated as the sum of the seed yield and stover yield.

3.8. Data Collection

To study the yield attributes and yields, following data were collected:

i) Plants per m^2

ii) Plant height (cm)

iii) Number of branches per plant

iv) No. of siliqua per plant

v) Length of siliqua

vi) No. of seeds per siliqua

vii) 1000 seed weight (g)

viii) Seed yield per plant (g)

ix) Seed yield per hectare (kg)

x) Stover yield per hectare (kg)

xi) Biological yield (kg)

xii) Harvest Index (%)

xiii) Oil content (%)

xiv) Oil yield per hectare (kg)

3.8.1 Number of plants per m^2 at harvest

One square meter area was selected randomly with the help of quadrate. The plants lying on this area was counted. Three of such samples were averaged and then it was expressed as number of plants m^{-2}.

3.8.2 Plant height

The height of ten plants was measured from ground level (stem base) to the tip of the plant. Mean plant height was calculated and expressed in cm.

3.8.3 Number of branches per plant

The number of branches of ten randomly sampled plants were counted and recorded. Average value of ten plants was recorded as number of branches per plant.

3.8.4 Number of siliquae per plant

Siliquae of ten plants was counted and divided by ten which indicated the number of siliqua per plant.

3.8.5 Length of siliqua

Length of siliquae from sampled plants were counted and divided by ten which indicated the individual length of siliqua.

3.8.6 Number of seeds per siliqua

The number of seeds was counted by splitting twenty siliquae which were sampled randomly from sampled plants and then mean value was determined.

3.8.7 Weight of 1000 seeds

Thousand seeds were randomly counted from the total seeds of each sample. Then the weight was taken by a digital balance. The 1000 seed weight was recorded in gm.

3.8.8 Seed yield per plant

The separated seeds of ten plants were collected, cleaned, dried and weighed properly. The average seed yield per plant was then calculated.

3.8.9 Seed yield per hectare

After threshing, cleaning and drying, total seed yield from the harvested area was recorded and was converted to kg ha^{-1}.

3.8.10 Oil content

The oil content of seed was determined by Soxhlet method (Hughes, 1969) in percentage (%). This was done in Oil Seed Research Centre, Bangladesh Agricultural Research Institute, Jodebpur, Gazipur-1701.

3.8.11 Oil yield

Yield of oil was calculated from the percent oil in the seed samples multiplied by seed yield (kg ha^{-1}) and expressed in kg ha^{-1}.

3.8.12 Stover yield per hectare

After the separation of seeds from plant, the straw and shell per plot was dried separately and the weight was recorded. These were then converted into stover yield (kg ha^{-1}).

3.8.13 Biological yield per hectare

The summation of seed yield and stover yield per hectare gave the biological yield.

3.8.14 Harvest Index

Harvest Index was calculated by the following formula of Donald and Hamblin (1976).

$$\text{Harvest index (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.9 Statistical analysis

The data were analysed following Analysis of Variance (ANOVA) technique and mean differences were adjusted by the Multiple Comparison test (Gomez and Gomez, 1984) using the statistical computer programme ALPHA and MSTAT-C v.1.2. Means were compared by using LSD test at 5% level of significance. The correlation analysis was done by SPSS v. 13.1 Software. Regressing were measured and plotted with the Microsoft Excel 2003 Software.

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to study the performance of rapeseed c.v. SAU Sarisha-1 as influenced by different nitrogen levels and number of weeding. The results of the present investigation have been presented, discussed and compared as far as possible with the results of other scientists.

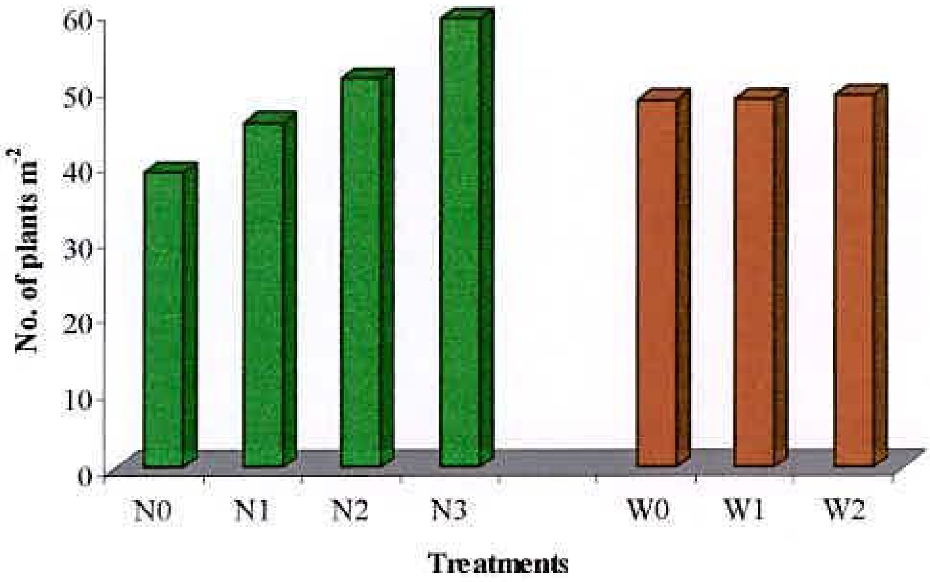
4.1 Plants per m^2

Effect of nitrogen

In this study, the number of plant m^{-2} was significantly increased with the increment of nitrogen levels (Figure 4.1). The maximum number of plants (59.13) per m^2 were found from 150 kg N ha^{-1} which was statistically superior than other nitrogen doses. The plots without treated nitrogen (control) produced the minimum number of plants per m^2 in this experiment. The maximum number of plant produced by 150 kg N ha^{-1} was 51.53% higher than control. The higher number of plants produced by higher N doses was due to more protein synthesis and increased vigour facilitated by nitrogen. The lowest number of plant in control plots was due to lack of nitrogen some plants were died. Murtaza and Paul (1989) also found similar result.

Effect of weeding

The number of weeding had no significant effect on the number of plant m^{-2} but it increased the number of plants m^{-2} progressively with the increment of the number of weeding. The maximum number of plants m^{-2} was produced from 2 hand weeding at 25 and 40 DAS where unweeded control gave the lowest number of plant m^{-2} (Figure 4.1).



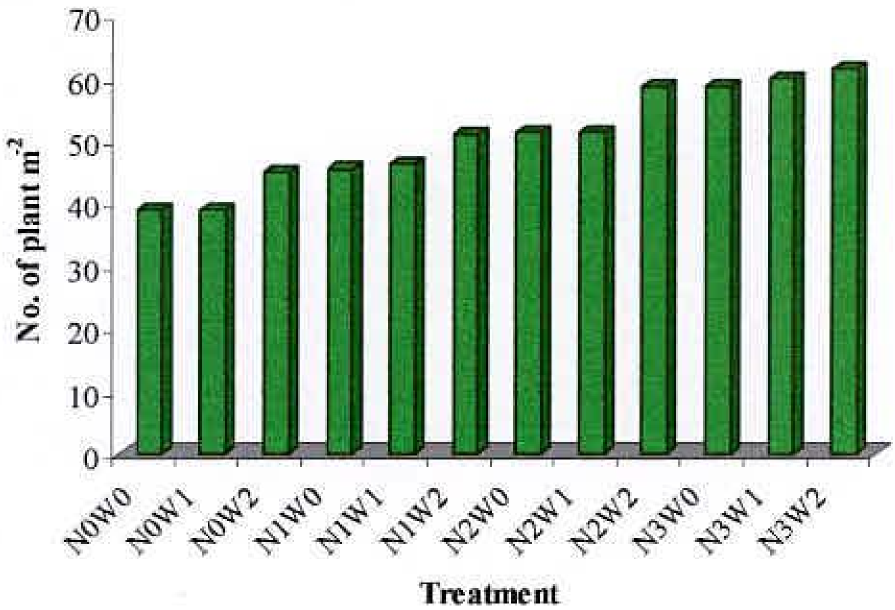
N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig 4.1 Number of plants m^{-2} of rapeseed c.v. SAU Sarisha-1 as affected by different nitrogen levels and number of weeding

Interaction effect of nitrogen levels and number of weeding

The interaction effect between nitrogen levels and number of weeding affected the number of plants m^{-2} significantly (Figure 4.2). The combination of 150 kg N ha^{-1} with two hand weeding (N_3W_2) produced the maximum number of plants m^{-2} which was statistically similar to those of N_3W_1 and N_3W_0, respectively. The combination of no nitrogen and no weeding produced the lowest number of plants m^{-2}.



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

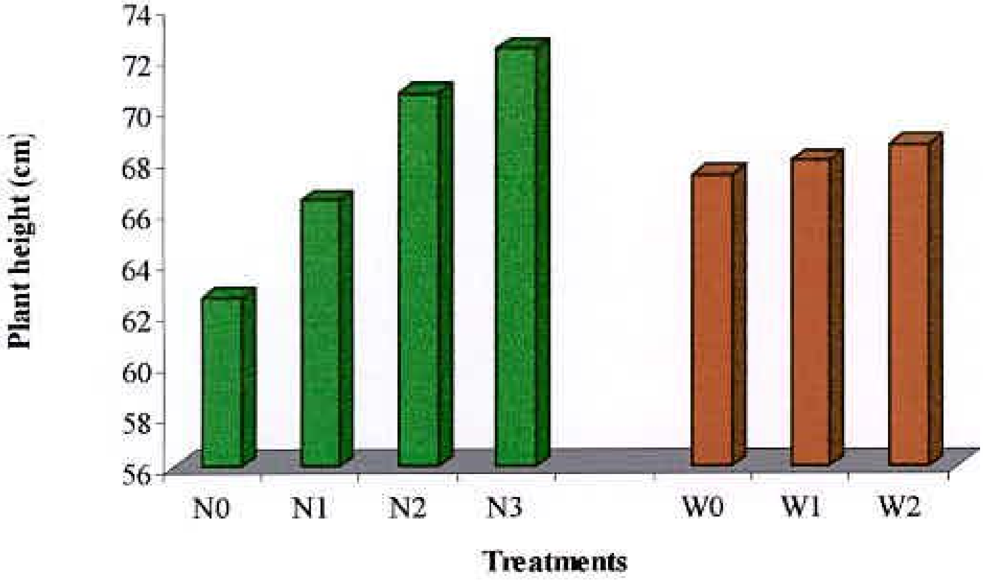
W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.2 Number of plants m^{-2} of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

4.2 Plant height

Effect of nitrogen levels

Nitrogen levels significantly increased the plant height in this experiment (Figure 4.3). The maximum height (72.40 cm) of plant was observed from 150 kg N ha^{-1}. Plant height was progressively increased with the increase of nitrogen levels. The maximum plant height (72.40 cm) with 150 kg N ha^{-1} and second highest plant height (70.63 cm) was 15.59% and 12.77% greater than control plant height (62.63 cm). The increment of plant height with increased nitrogen was due to more expansion of plant cells rendering the elongation of tissues. These findings are in agreement with those of Singh *et al.* (2003), Tripathi and Tripathi (2003), Singh *et al.* (2002) and Tarafder and Mondal (1990). They obtained tallest plant height of mustard with the application of N at 120 kg ha^{-1}. Patel (1998), Gurjar and Chauhan (1997), Thakuria and Gogoi (1996) and Shamsuddin *et al.* (1987), observed taller plant height at 140 kg N ha^{-1} which was identical with that of 105 kg N ha^{-1}. Maximum plant height was recorded at 100 kg N ha^{-1} as reported by Patel *et al.* (2004).



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

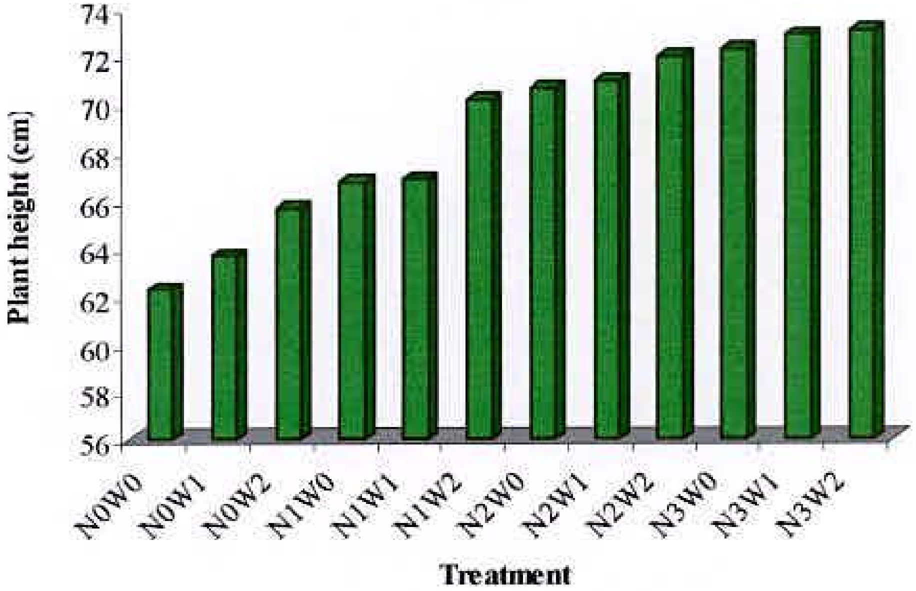
Fig 4.3 Plant height of rapeseed c.v. SAU Sarisha-1 as affected by different nitrogen levels and number of weeding

Effect of weeding

Plant height of the rapeseed c.v. SAU Sarisha-1 was also influenced by the number of weeding (Figure 4.3). The tallest plants were produced with two weeding at 25 and 40 DAS which was followed by one weeding treatment. The plant height was found minimum with no weeding. Weeding facilitates the plants to have more resources which rendering the increased plant height in this experiment. This results was supported by Gaffer (1984).

Interaction effect of nitrogen levels and number of weeding

The combination of nitrogen doses and number of weeding also affected the plant height. Maximum plant height was found in plots having the combination of 150 kg N ha^{-1} and two weedings at 25 and 40 DAS (N_3W_2) which was statistically similar with those of N_3W_1 and N_3W_0. The lowest plant height was found from the interaction of no nitrogen and no weeding (control).



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.4 Plant height of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

4.3 Number of branches per plant

Number of branches per plant is the result of genetic make up of the crop and environmental conditions, which plays a remarkable role towards the final seed yield of the crop (Sana *et al.*, 2003). In this study it indicated that the number of branches per plant varied significantly with different nitrogen levels and number of weeding.

Effect of nitrogen levels

Number of branches plant^{-1} was significantly increased with different levels of nitrogen in this experiment (Table 4.1). The maximum number of branches per plant (5.75) was produced by the highest dose of nitrogen (150 kg ha^{-1}). It was 20.04% higher than the branches produced without nitrogen. The nitrogen doses of 120 kg ha^{-1} and 90 kg ha^{-1} produced 4.91 and 4.38 branches plant^{-1} which were statistically different. These findings were supported by Tripathi and Tripathi (2003), Ozer (2003), Singh *et al.* (2003), Sharma and Jain (2002), Singh *et al.* (2002), Patel (1998), Tarafder and Mondal (1990), Shamsuddin *et al.* (1987) and Mondal and Gaffer (1983) who obtained significantly higher number of primary branches per plant by applying nitrogen up to 150 kg ha^{-1}.

Table 4.1 Yield attributes of rapeseed c.v. SAU Sarisha-1 as affected by different nitrogen levels

Nitrogen levels	No. of branches plant^{-1}	No. of siliquae plant^{-1}	Length of siliqua (cm)	No. of seeds siliqua^{-1}	1000-seed weight (g)
N_0	3.65	56.70	4.80	17.12	2.09
N_1	4.38	62.00	5.36	17.67	2.72
N_2	4.91	72.54	5.37	19.91	3.16
N_3	5.75	68.12	5.64	18.83	2.88
LSD 0.05	**0.18**	**0.38**	**0.10**	**0.30**	**0.16**
CV (%)	**4.02**	**7.77**	**3.09**	**8.70**	**6.32**

N_0= 0 kg N ha^{-1}, N_1= 90 kg N ha^{-1}, N_2= 120 kg N ha^{-1}, N_3= 150 kg N ha^{-1}

Effect of weeding

Number of branches was also significantly influenced by number of weeding (Table 4.2). The increase in the number of hand weeding increased the number of branches plant^{-1}. Maximum number of branches per plant (4.92) was observed with two weeding at 25 and 40 DAS. One weeding treatment produced the second highest number of branches plant^{-1} where no weeding (control) treatment gave the lowest number of branches plant^{-1}. Chemale and Fleck (1984) also found same results.

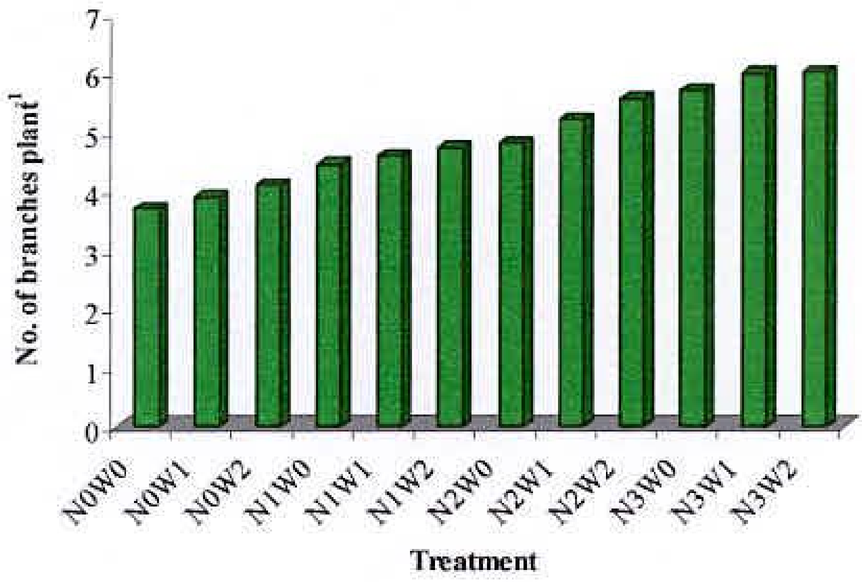
Table 4.2 Yield attributes of rapeseed c.v. SAU Sarisha-1 as affected by number of weeding

No. of weeding	No. of branches plant^{-1}	No. of siliqua plant^{-1}	Length of siliqua (cm)	No. of seeds siliqua^{-1}	1000-seed weight (g)
W_0	4.44	64.01	5.02	18.11	2.55
W_1	4.66	64.97	5.31	18.40	2.72
W_2	4.92	65.72	5.52	18.64	2.86
LSD 0.05	**0.15**	**0.97**	**0.09**	**0.26**	**0.14**
CV (%)	**4.02**	**7.77**	**3.09**	**8.70**	**6.32**

W_0= No weeding, W_1= One hand weeding at 25 DAS, W_2= Two hand weeding at 25 and 40 DAS

Interaction effect of nitrogen levels and number of weeding

Number of branches plant^{-1} was also affected by the interaction between nitrogen levels and number of weeding (Figure 4.5). The interaction between 150 kg N ha^{-1} and two hand weeding at 25 and 40 DAS (N_3W_2) produced the maximum numbér of branches plant^{-1} (6.01) which was at par with those of N_3W_1 and N_3W_0, respectively. It reveals that nitrogen contributes more than weeding in the production of branches of rapeseed plant. The lowest number of branches plant^{-1} was observed from the interaction of no nitrogen and no weeding (N_0W_0). Plants were influenced with nitrogen 'at the rate of 150 kg ha^{-1} and two hand weeding may have been produced maximum dry matter which ultimately increased the production of branches plant^{-1}.



N_0= 0 kg N ha^{-1} | W_0= No weeding
N_1= 90 kg N ha^{-1} | W_1= One hand weeding at 25 DAS
N_2= 120 kg N ha^{-1} | W_2= Two hand weeding at 25 and 40 DAS
N_3= 150 kg N ha^{-1}

Fig. 4.5 No. of branches plant^{-1} of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

4.4 Number of siliquae per plant

Number of siliquae per plant is the result of genetic make up of the crop and environmental conditions (Sana *et al.*, 2003). It is an important yield contributing character which has a great effect on final yield.

Effect of nitrogen levels

In this experiment, number of siliquae per plant was greatly affected by nitrogen levels (Table 4.1). Among the four different nitrogen doses, 120 kg N ha^{-1} gave the maximum number of siliquae per plant of rapeseed line. The second highest number of siliquae per plant was found from 150 kg N ha^{-1} and 90 kg N ha^{-1}. Control (without N) produced the lowest number of siliqua in this study. Similar result also obtained by Shukla *et al.* (2002), Singh *et al.* (2003), Tarafder and Mondal (1990) and

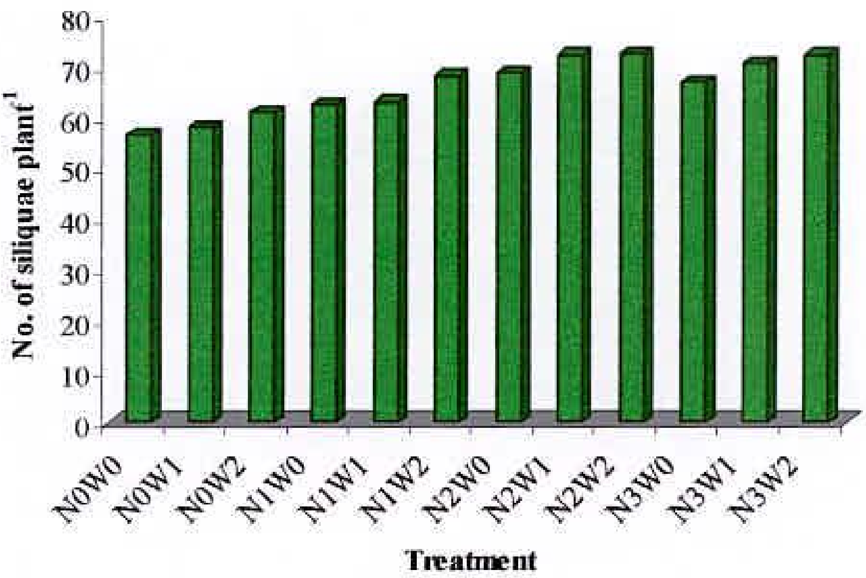
Shamsuddin *et al.* (1987). On the other hand, higher number of siliquae per plant obtained at the 80 kg N ha^{-1} by Khan *et al.* (2003), Sharma and Jain (2002) and Patel (1998).

Effect of weeding

Weeding did not affect significantly on the number of siliquae per plant of rapeseed (Table 4.2). Numerically, the maximum number of siliquae per plant (65.72) was observed from two hand weeding which was at per with one weeding (64.97). The no weeding i.e. control treatment gave the lowest number of siliquae per plant (64.01). This result was corroborated with the results found by Chemale and Fleck (1984), Yadav *et al.* (1984), Sarkar and Mondal (1985).

Interaction effect of nitrogen levels and number of weeding

The interaction of nitrogen levels and number of weeding had significant effect on the number of siliquae per plant (Figure 4.6). From this study, it was observed that the interaction between 120 kg N ha^{-1} and two hand weeding i.e. N_2W_2 produced maximum number of siliquae $plant^{-1}$ (72.70) which was 28.62% higher than control. It was statistically at per with N_2W_1, N_3W_1 and N_3W_2. The lowest number of siliquae was found from the control combination (N_0W_0). The optimum rate of nitrogen and weeding operation probably influenced plants to have more dry matter which favourable partitioned towards more production of siliquae $plant^{-1}$.



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.6 No. of siliquae plant^{-1} of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

4.5 Length of siliqua

Effect of nitrogen levels

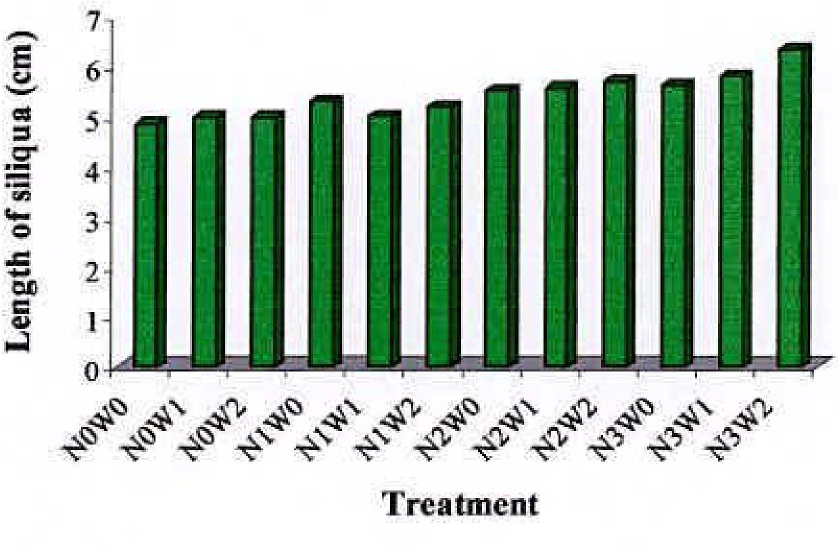
Nitrogen levels had significant effect on the length of siliqua of rapeseed line (Table 4.1). The maximum length of siliqua (5.64 cm) was found from 150 kg N ha^{-1}. The second highest length of siliqua (5.37) that was observed with the treatment 120 kg N ha^{-1} which was statistically identical with 90 kg N ha^{-1}. The control plot without any nitrogen produced the minimum length of siliqua in this study. Singh (2002), Singh *et al.* (2002) and Shukla and Kumar (1997) reported the highest length of siliqua following 120 kg N ha^{-1}.

Effect of weeding

Weeding had also a significant role in the elongation of siliqua (Table 4.2). In this study, the maximum length of siliqua was observed from two weeding at 25 and 40 DAS where no weeding treatment produced the minimum length of siliqua. One weeding produced the second highest length of siliqua which was statistically different from others. Chemale and Fleck (1984) supported this result.

Interaction effect of nitrogen levels and number of weeding

From this study, it was found that the interaction between 150 kg N ha^{-1} with two weeding produced the maximum length of siliqua (6.34) which was statistically at per with N_3W_1, N_3W_0 and N_3W_2 (Figure 4.7). The lowest siliqua length was observed from the combination of N_0W_0 which was at per with N_0W_1 and N_0W_2.



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.7 Length of siliquae of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

4.6 Number of seeds per siliqua

Number of seeds per siliqua is also an important factor which contributes towards seed yield. Nitrogen levels as well as number of weeding had a significant effect on the number of seeds siliqua^{-1} in this study.

Effect of nitrogen levels

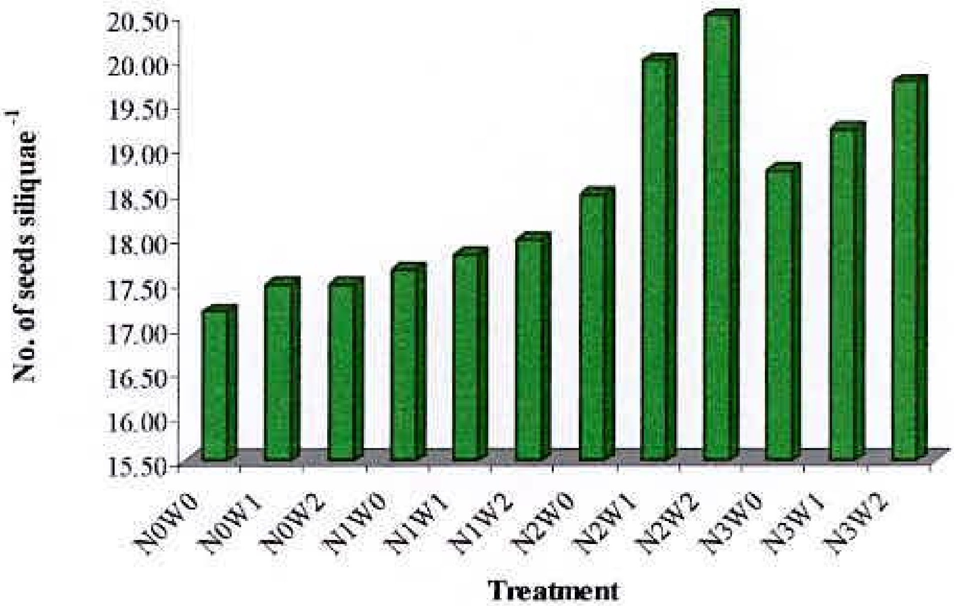
Nitrogen levels had significant effect on the production of seeds per siliqua (Table 4.1). In this experiment, it was observed that the nitrogen dose of 120 kg ha^{-1} produced the highest number of seeds per siliqua (19.91) which was followed by 150 kg N ha^{-1}. The lowest number of seeds per siliqua was found from control. Singh (2002), Sukla *et al.* (2002), Tarafder and Mondal (1990) and Mondal and Gaffer (1983) observed significant effect of nitrogen at rate of 120 kg ha^{-1} on the production of seeds per siliqua. Sharma and Jain (2002) obtained higher number of seeds per siliqua following 80 kg N ha^{-1}. Patel (1998) also obtained similar response of nitrogen on number of seeds per siliqua.

Effect of weeding

Weeding had also a great effect on the production of seeds per siliqua (Table 4.2). From this study it was observed that two hand weeding produced the maximum number of seeds per siliqua which was statistically identical with the number of seeds per siliqua found from one weeding. The lowest number of seeds per siliqua was produced with unweeded control. This result is also supported by Sarkar and Mondal (1985).

Interaction effect of nitrogen levels and number of weeding

Interaction between nitrogen levels and number of weeding has also a great influence on the number of seeds per siliqua in this experiment (Figure 4.8). The highest number of seeds per siliqua was observed from N_2W_2 (120 kg N ha^{-1} and two hand weeding) which was at per with N_3W_1, N_3W_0 and N_3W_1. The lowest number of seeds per siliqua was observed from no weeding and 0 kg N ha^{-1}. The maximum number of seeds per siliqua was probably resultant effect of increased siliquae length that accommodate more number of seeds.



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.8 Number of seeds per siliqua of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

4.7 1000-seed weight

The weight of seed is related with the magnitude of seed development because it is an important yield determinant factor and plays a decisive role in expression yield potential of a variety (Sana *et al.*, 2003).

Effect of nitrogen levels

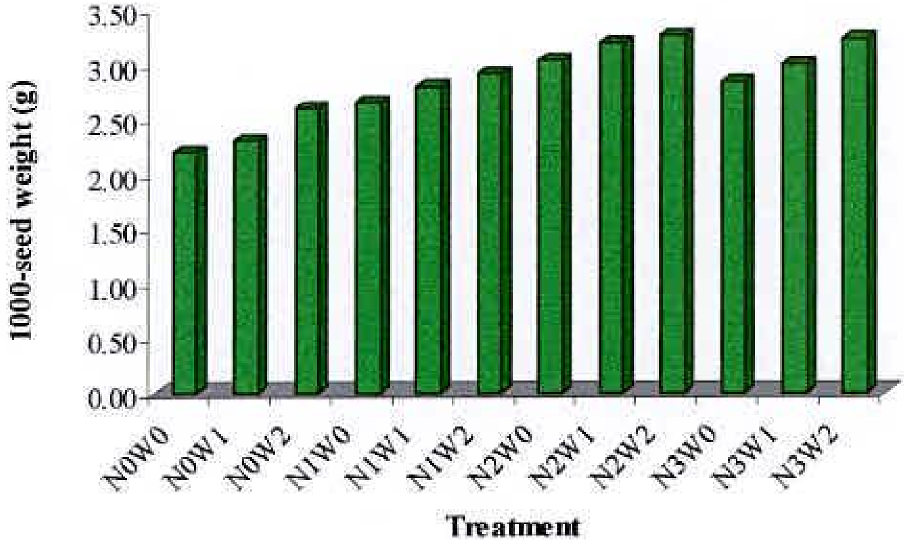
Nitrogen levels significantly affected the weight of thousand seed in this experiment (Table 4.1). Among the nitrogen levels, the dose of 120 kg N ha^{-1} produced the maximum weight of 1000-seed (3.16 g). The lowest seed weight was observed in the plots having no nitrogen (control). But, Ozer (2003), Singh *et al.* (2002), Sukla *et al.* (2002) and Shamsuddin *et al.* (1987) obtained highest 1000-seed weight N at120 kg ha^{-1}. Sharma and Jain (2002) also obtained highest 1000-seed weight following at 80 kg N ha^{-1}.

Effect of weeding

Thousand seed weight was also significantly influenced by weeding (Table 4.2). In the study, the maximum seed weight was observed from two hand weeding at 25 and 40 DAS which was statistically identical with the 1000-seed weight found from one weeding at 25 DAS. Weight of 1000-seed was lowest with no weeding treatment (control).

Interaction effect of nitrogen levels and number of weeding

The interaction between nitrogen levels and number of weeding significantly affected the weight of 1000-seed (Figure 4.9). The maximum weight of 1000-seed was observed from the combination of 120 kg N ha^{-1} and two hand weeding (N_2W_2), which was at per with other combination of any weeding treatment with 120 kg ha^{-1} or 150 kg ha^{-1} N. The lowest weight of 1000-seed was observed from the treatment combination N_0W_0.



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.9 1000-seed weight of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

4.8 Seed yield per plant

Seed yield per plant is the cumulative effect of different yield contributing characters such as number of branches, number of siliquae per plant, number of seed per siliqua, 1000-seed weight etc. In this study, seed yield per plant was significantly influenced by different nitrogen levels and number of weeding having variation of those parameters mentioned above.

Effect of nitrogen levels

The different rate of nitrogen significantly increased seed yield per plant. The increment of nitrogen doses increased the seed yield per plant up to a certain levels and then decreased (Table 4.3). The rate of nitrogen at 120 kg ha^{-1} significantly produced highest seed yield per plant (7.03 g) over 150 kg ha^{-1} (6.26 g), 90 kg N ha^{-1} (3.36 g) and control (1.93 g). The increment of seed yield per plant with 120 kg N ha^{-1} over control was 264.67% higher. Tuteja *et al.* (1996), Shamsuddin *et al.* (1987) and Murtaza and Paul (1989) also observed similar results.

Effect of weeding

The number of weeding had a significant role on seed yield per plant in the experiment (Table 4.4). Two hand weeding at 25 and 40 DAS produced the maximum seed yield per plant (4.95 gm) which was statistically similar with one weeding. The lowest seed yield per plant was 4.32 g which was observed from control (no weeding). The highest seed yield with two hand weeding was 14.58% higher than control.

Interaction effect of nitrogen levels and number of weeding

The interaction of nitrogen levels and number of weeding had also significant effect on the seed yield per plant (Table 4.5). Maximum seed yield per plant was observed from the treatment combination N_2W_2 (120 kg N ha^{-1} and two hand weeding) which was statistically similar with N_3W_2 and N_3W_1. The lowest seed yield (1.90 g) was observed from control combination of NoW_0 and it was statistically at per with N_0W_1 (2.10 g). The highest seed yield per plant with N_2W_2 was 321.57 % higher than the lowest seed yield per plant with control treatment.

In this experiment, the maximum seed yield plant^{-1} was evident with the favourable treatment combination due to the maximum production of seed yield contributing parameters with same treatment combination.

Table 4.3 Yield and harvest index of rapeseed c.v. SAU Sarisha-1 as affected by nitrogen levels

Nitrogen levels	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
N_0	1.93	796.3	1223.4	2019.7	37.75
N_1	3.36	1369.5	2258	3627.5	39.43
N_2	7.03	2343.4	2810.6	5154	45.47
N_3	6.26	2192.6	2850.3	5042.9	43.48
LSD 0.05	**0.30**	**11.10**	**63.67**	**143.00**	**1.59**
CV (%)	**6.66**	**6.79**	**5.85**	**3.69**	**3.93**

N_0= 0 kg N ha^{-1}, N_1= 90 kg N ha^{-1}, N_2= 120 kg N ha^{-1}, N_3= 150 kg N ha^{-1}

Table 4.4 Yield and harvest index of rapeseed c.v. SAU Sarisha-1 as affected by number of weeding

No. of weeding	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
W_0	4.32	1540.10	2139.10	3679.20	41.86
W_1	4.67	1673.20	2217.20	3890.40	43.01
W_2	4.95	1812.20	2499.30	4311.50	42.03
LSD 0.05	**0.26**	**96.22**	**55.14**	**123.80**	**1.38**
CV (%)	**6.66**	**6.79**	**5.85**	**3.69**	**3.93**

W_0= No weeding, W_1= One hand weeding at 25 DAS, W_2= Two hand weeding at 25 and 40 DAS

Table 4.5 Yield and harvest index of rapeseed c.v. SAU Sarisha-1 as affected by the combined effect of nitrogen levels and number of weeding

Nitrogen levels × No. of weeding	Seed yield $plant^{-1}$ (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
N_0W_0	1.90	833.70	1218.50	2052.20	35.39
N_0W_1	2.10	913.00	1250.60	2163.60	42.20
N_0W_2	2.98	1251.20	1800.10	3051.30	41.01
N_1W_0	3.40	1335.20	1983.20	3318.40	40.24
N_1W_1	3.70	1520.10	2775.20	4295.30	40.62
N_1W_2	6.50	2223.40	2855.30	5078.70	43.78
N_2W_0	6.10	2046.10	2780.30	4826.40	42.39
N_2W_1	6.60	2383.60	2843.40	5227.00	45.47
N_2W_2	8.01	2430.20	2914.50	5344.70	45.60
N_3W_0	6.30	2147.20	2810.20	4957.40	43.31
N_3W_1	7.20	2375.60	2990.40	5366.00	44.27
N_3W_2	7.50	2406.20	3004.60	5410.80	44.47
LSD 0.05	**0.52**	**192.40**	**110.30**	**147.60**	**2.76**
CV (%)	**6.66**	**6.79**	**5.85**	**3.69**	**3.93**

N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

4.9 Seed yield per hectare

Effect of nitrogen levels

Table 4.3 showed the significant variations in seed yield per hectare ranging from 796.3 to 2343.4 kg at different nitrogen levels. The treatment N_2 i.e. 120 kg N ha^{-1} produced significantly the highest seed yield (2343.4 kg ha^{-1}) where control treatment (N_0) produced the lowest yield (796.3 kg ha^{-1}). The maximum seed yield ha⁻

^{1} with 120 kg N ha^{-1} was 6.87%, 71.11% and 194.28% higher than the yield obtained from 150 kg, 90 kg and 0 kg N ha^{-1}, respectively. This indicated that the nitrogen dose must be optimum to achieve the highest seed yield. The higher seed yield per hectare was also obtained with same nitrogen rate reported by Singh and Prasad (2003), Singh *et al.* (2003), Sukla *et al.* (2002), Singh (2002), Singh *et al.* (2002), Shukla and Kumar (1997), Tuteja *et al.* (1996) and Shamsuddin *et al.* (1987). On the other hand, highest seed yield per hectare obtained by Singh (2004), Sharma and Jain (2002), Ghosh *et al.* (2001), Khan *et al.* (2003), Singh *et al.* (1998), Thakuria and Gogoi (1996) at the rate of nitrogen application at 80 kg ha^{-1}.

Effect of weeding

Weeding had also an important role in increasing the seed yield per hectare in this experiment (Table 4.4). Seed yield was increased with the increasing of weeding operation. The maximum seed yield per hectare (1812.20 kg ha^{-1}) was obtained from two hand weeding at 25 and 40 DAS (W_2) where W_0 (control) gave the lowest seed yield (1540.10 kg ha^{-1}). One weeding at 25 DAS gave 1673.20 kg ha^{-1} seed yield which was statistically different than other treatments. The seed yield with two weeding and one weeding were17.66 % and 8.64% higher than the control. This result was supported by Singh *et al.* (1983), Chemale and Fleck (1984), Sarkar and Mondal (1985), Bhadoria and Chauhan (1995).

Interaction effect of nitrogen levels and number of weeding

Interaction of nitrogen levels and number of weeding had significant effect on the seed yield per hectare (Table 4.5). In this experiment, the maximum seed yield (2430.24 kg ha^{-1}) was obtained from the combination of 120 kg N ha^{-1} and two hand weeding at 25 and 40 DAS (N_2W_2). It was statistically at per with N_3W_2, N_3W_1 and N_2W_1. The combination of no nitrogen and no weeding (control) gave the lowest seed yield. The highest yield with N_2W_2 was 191.54% higher than the control (N_0W_0).

4.10 Stover yield

Effect of nitrogen levels

The nitrogen application favorably influenced the stover yield and the difference among the consecutive levels was significant (Table 4.3). The application of 150 kg N ha^{-1} gave the highest stover yield (2850.30 kg ha^{-1}) which was statistically similar with 120 kg N ha^{-1} (2810.20 kg ha^{-1}). The lowest stover yield was observed in control plots (1223.40 kg ha^{-1}). These findings were in agreement with that of Singh and Prasad (2003) and Singh *et al.* (2002). But, Meena *et al.* (2002) observed higher stover yield of mustard at the nitrogen rate of 60 kg ha^{-1}.

Effect of weeding

Stover yield was significantly differed with different weeding treatments (Table 4.4). The significantly highest stover yield was found from two hand weedings which was superior to one hand weeding and no weeding treatments. Control treatment or no weeding gave the lowest stover yield in this experiment.

Interaction effect of nitrogen levels and number of weeding

Stover yield of rapeseed c.v. SAU Sarisha-1 was also affected by different treatment combination of nitrogen levels and number of weeding (Table 4.5). Stover yield was found to be highest with the combination of 150 kg N ha^{-1} with two hand weeding (N_3W_2) which statistically at per with N_3W_1 and N_2W_2. Stover yield was lowest with the treatment combination of N_0W_0 (control).

4.11 Biological yield

Biological yield is the summation of seed yield and stover yield which was greatly influenced by different nitrogen levels and number of weeding.

Effect of nitrogen levels

The biological yield was greatly affected by nitrogen levels. Biological yield was increased with the increment of nitrogen doses (Table 4.3). The maximum biological yield (5042.90 kg ha^{-1}) was observed from 150 kg N ha^{-1} which was statistically similar with the yield obtained from 120 kg N ha^{-1}. The lowest biological yield (2019.70 kg ha^{-1}) was found from no nitrogen application (control).

Effect of weeding

Biological yield in this experiment was increased with more weeding. The maximum biological yield (4311.5 kg ha^{-1}) was observed from two hand weeding at 25 and 40 DAS (W_2) which was statistically superior than one hand weeding (W_1) and unweeded control (W_0).

Interaction effect of nitrogen levels and number of weeding

Table 4.5 showed that the combined effect of nitrogen levels and number of weeding influenced the biological yield in the present study. The treatment N_3W_2 produced the maximum biological yield (5410.80 kg ha^{-1}) which was at per with

N_3W_1 (5366.00 kg ha^{-1}) and N_2W_2 (5344.70 kg ha^{-1}). The treatment N_0W_0 produced the lowest biological yield (2052.20 kg ha^{-1}).

4.12 Harvest index

Harvest index is the ratio of economic yield and biological yield and it was also influenced by nitrogen levels and number of weeding.

Effect of nitrogen levels

In this study, different nitrogen levels significantly affected the harvest index of rapeseed c.v. SAU Sarisha-1 (Table 4.3). The significantly highest harvest index (45.47%) was observed with 120 kg N ha^{-1}. Treatments 150 kg N ha^{-1} and 90 kg N ha^{-1} showed the harvest index of 43.48% and 39.43%, respectively which were statistically different from each other. Harvest index was lower in control plots without nitrogen. Similar result was also observed by Shukla and Kumar (1997) at the same nitrogen levels.

Effect of weeding

Wedding was also an important in this experiment to affect the harvest index (Table 4.4). In this study one weeding (W_1) gave the maximum harvest index (43.01%) which was statistically similar with two weeding (42.03%). Unweeded control treatment showed the lowest value of harvest index (41.86%).

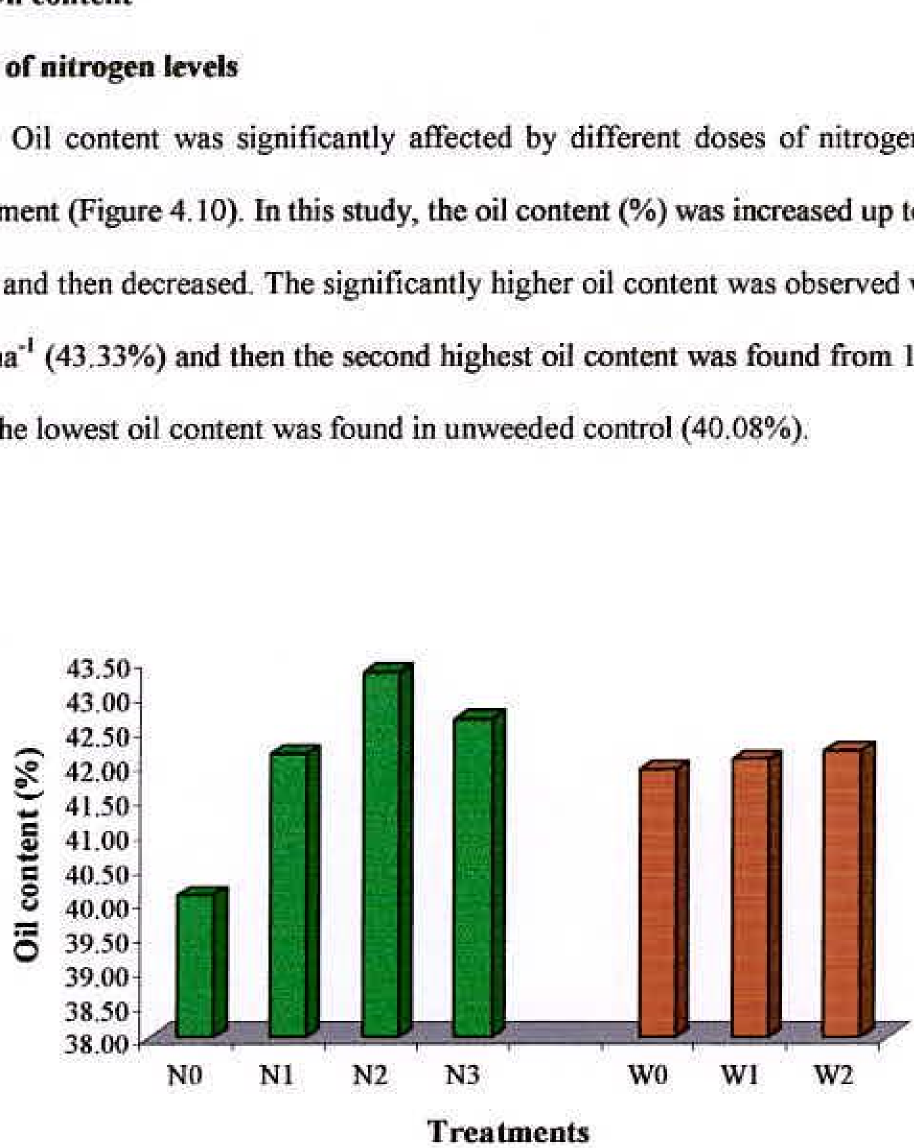
Interaction effect of nitrogen levels and number of weeding

Harvest index was influenced by different combination of nitrogen levels and number of weeding (Table 4.5). The highest harvest index (45.60%) was observed from the treatment N_2W_2 which was followed by N_2W_1, N_3W_2, N_3W_1 and N_1W_2. The treatment N_0W_0 gave the lowest harvest index (35.39%).

4.13 Oil content

Effect of nitrogen levels

Oil content was significantly affected by different doses of nitrogen in this experiment (Figure 4.10). In this study, the oil content (%) was increased up to 120 kg N ha^{-1} and then decreased. The significantly higher oil content was observed with 120 kg N ha^{-1} (43.33%) and then the second highest oil content was found from 150 kg N ha^{-1}. The lowest oil content was found in unweeded control (40.08%).



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

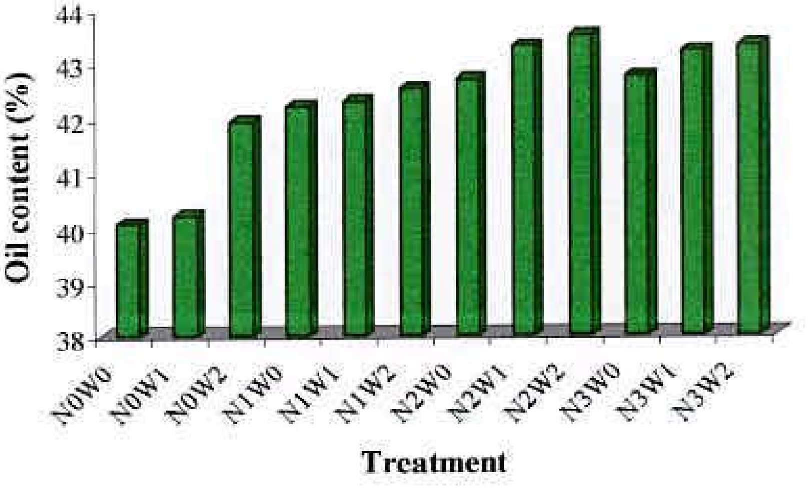
Fig. 4.10 Oil content (%) of rapeseed c.v. SAU Sarisha-1 as affected by different nitrogen levels and number of weeding

Effect of weeding

In the present study the oil content was increased slightly with the increase of weeding but it was not statistically significant (Figure 4.10). However, the highest oil content was observed with two hand weeding and the lowest oil content was found in unweeded control.

Interaction effect of nitrogen levels and number of weeding

The interaction between nitrogen levels and number of weeding had a significant influence on the oil content of rapeseed line (Figure 4.11). The highest oil content (43.5%) was observed with the treatment N_2W_2 which was followed by N_3W_2, N_2W_1 and N_3W_1. Oil content was found to be lowest with the treatment N_0W_0.



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.11 Oil content (%) of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

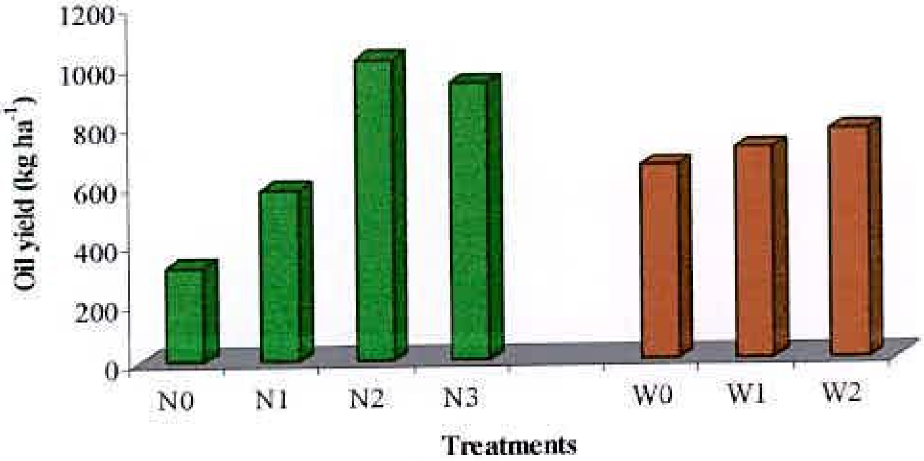
4.14 Oil yield

Effect of nitrogen

The effect of nitrogen on oil yield of rapeseed significantly increased up to 120 kg N ha^{-1}. Nitrogen at 120 kg ha^{-1} produced maximum oil yield (1015.3 kg ha^{-1}) compared to 150 and 90 kg N ha^{-1} and lowest oil yield (391.1 kg ha^{-1}) obtained at control (Figure 4.12). Islam (2005) also observed similar result.

Effect of weeding

Number of weeding influenced the oil yield of rapeseed c.v. SAU Sarisha-1 (Figure 4.12). The significantly highest oil yield (771.00 kg ha^{-1}) was observed with two hand weeding (W_2) where unweeded control (W_0) produced the lowest oil yield of 653.2 kg ha^{-1}. One hand weeding (W_1) produced the second highest oil yield of 710.00 kg ha^{-1} oil yield.



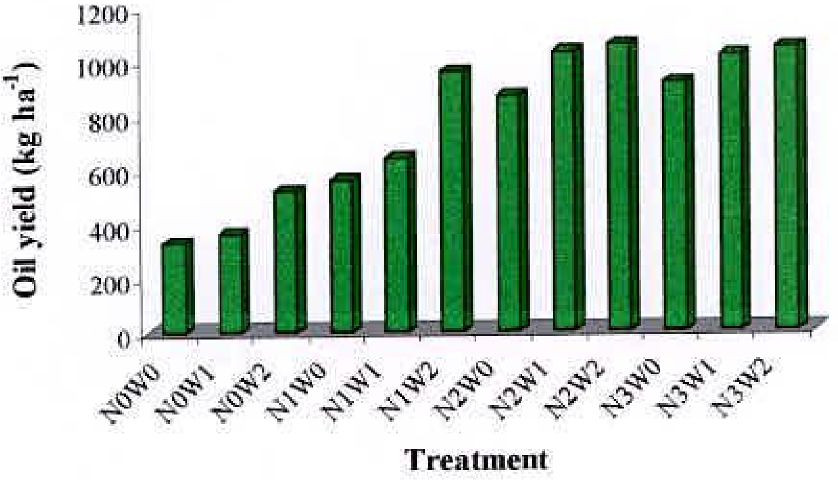
N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.12 Oil yield of rapeseed c.v. SAU Sarisha-1 as affected by different nitrogen levels and number of weeding

Interaction effect of nitrogen levels and number of weeding

In the present study, oil yield was affected with the combination effect of nitrogen levels and number of weeding (Figure 4.13). The highest oil yield of 1057.50 kg ha^{-1} was observed with the treatment N_2W_2 where N_0W_0 produced the lowest oil yield (333.90 kg ha^{-1}). The highest oil yield was also statistically similar with N_3W_2, N_3W_1 and N_2W_1.



N_0= 0 kg N ha^{-1}
N_1= 90 kg N ha^{-1}
N_2= 120 kg N ha^{-1}
N_3= 150 kg N ha^{-1}

W_0= No weeding
W_1= One hand weeding at 25 DAS
W_2= Two hand weeding at 25 and 40 DAS

Fig. 4.13 Oil yield of rapeseed c.v. SAU Sarisha-1 as affected by the interaction effect between nitrogen levels and number of weeding

4.15 Correlation and regression analyses

Table 4.6 revealed that number of branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliqua^{-1}, 1000-seed weight and seed yield plant^{-1} were positively correlated with each other. The intercorrelations were also significant. Number of branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliqua^{-1} and 1000-seed weight had a significant correlation with seed yield plant^{-1} with r values of 0.91, 0.97, 0.88 and 0.96, respectively. All of them were highly significant (significant at 0.01 level). The coefficients of determination also showed a positive linear and significant relation of number of branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliqua^{-1} and 1000-seed weight with seed yield plant^{-1} with R^2=0.8287**, R^2=0.9527**, R^2=0.7827*, R^2=0.8766**, respectively (Figure 4.14, 4.15, 4.16 and 4.17). The slope for number of siliquae plant^{-1} and seed yield plant^{-1} indicated that an increment of 1 siliqua plant^{-1} increased 0.37 g seed yield plant^{-1} (Figure 4.15).

Table 4.6 **Correlation between seed yield and yield attributes of rapeseed c.v. SAU Sarisha-1 as affected by the combination effect of nitrogen levels and number of weeding**

Parameters	No. of branches plant^{-1}	No. of siliquae plant^{-1}	No. of seeds siliqua^{-1}	1000-seed weight (g)	Seed yield plant^{-1} (g)
No. of branches plant^{-1}	1.00	0.88 **	0.84 **	0.84 **	0.91 **
No. of siliquae plant^{-1}		1.00	0.90 **	0.98 **	0.97 **
No. of seeds siliqua^{-1}			1.00	0.88 **	0.88 **
1000-seed weight (g)				1.00	0.96 **
Seed yield plant^{-1} (g)					1.00

** significant at the 0.01 level.

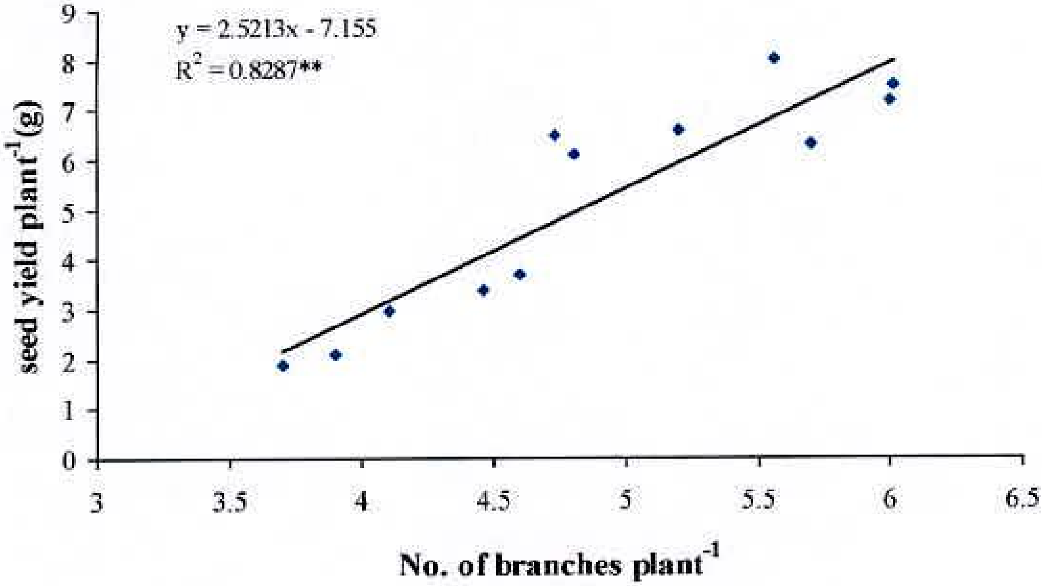


Fig. 4.14 Relationship between number of branches plant^{-1} and seed yield plant^{-1} of rapeseed c.v. SAU Sarisha-1

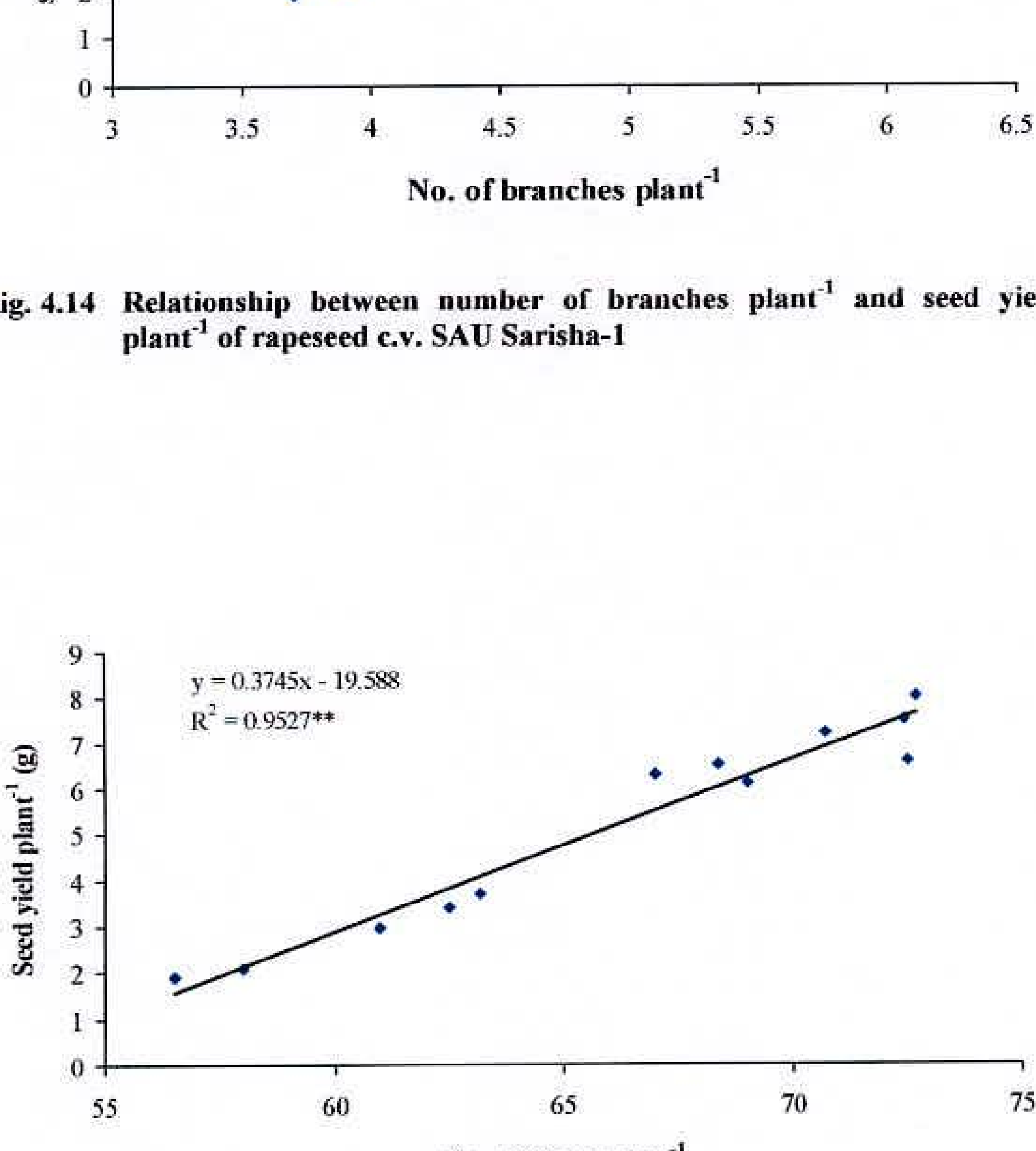


Fig. 4.15 Relationship between number of siliquae plant^{-1} and seed yield plant^{-1} of rapeseed c.v. SAU Sarisha-1

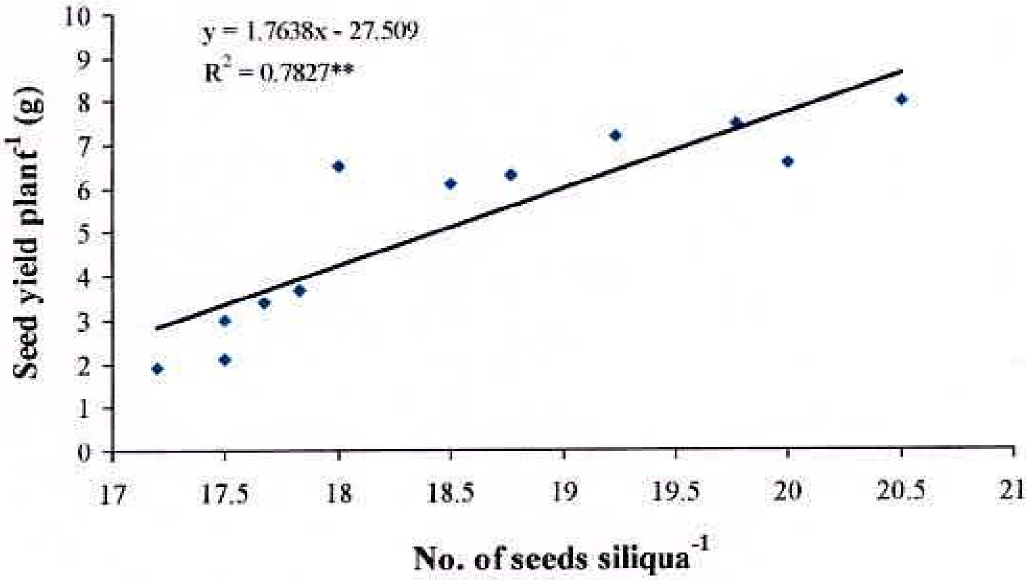


Fig. 4.16 Relationship between number of seeds siliqua^{-1} and seed yield plant^{-1} of rapeseed c.v. SAU Sarisha-1

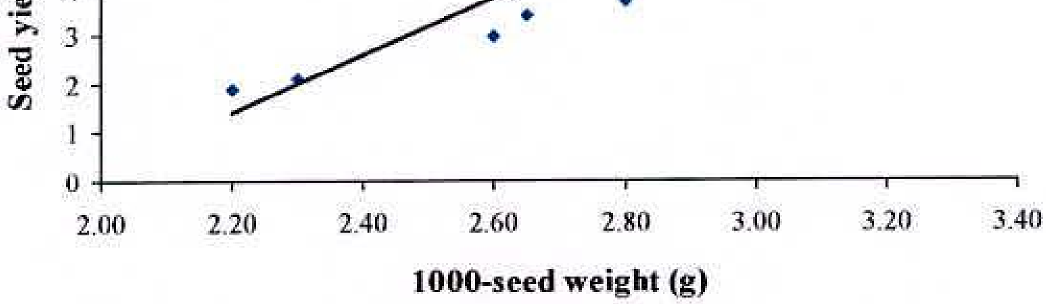


Fig. 4.17 Relationship between 1000-seed weight and seed yield plant^{-1} of rapeseed c.v. SAU Sarisha-1

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

A field experiment was conducted in the Rabi season (November-February) of 2005-2006 to study the response of rapeseed c.v. SAU Sarisha-1 in respect of yield, yield attributes and oil yield to different nitrogen levels and number of weeding. The treatment comprised of 4 levels of nitrogen and 3 levels of weeding. Different N levels were 0 kg N ha^{-1} (N_0), 90 kg N ha^{-1} (N_1), 120 kg N ha^{-1} (N_2) and 150 kg N ha^{-1} (N_3). The weeding treatments were no weeding (W_0), one weeding at 20 DAS (W_1) and two weeding at 20 and 45 DAS (W_2). The experiment was laid out in a factorial Randomized Complete Block Design (RCBD) with three replications.

A progressive increase in number of plants m^{-2} was observed with the increase of nitrogen levels. The maximum number of plants (59.13) per m^2 were found from 150 kg N ha^{-1} which was statistically superior to other nitrogen doses. The plots without nitrogen (control) produced the minimum number of plants per m^2 in this experiment. The maximum number of plant produced by 150 kg N ha^{-1} was 51.53% higher than control. The number of weeding had no significant effect on the number of plants m^{-2} but it increased the number of plants m^{-2} progressively with the increment of the number of weeding. The maximum number of plants m^{-2} was produced from 2 hand weeding at 25 and 40 DAS where control gave the lowest number of plant m^{-2}. The combination of 150 kg N ha^{-1} with two hand weeding (N_3W_2) produced the maximum number of plants m^{-2} which was statistically similar to those of N_3W_1 and N_3W_0. The combination of no nitrogen and no weeding produced the lowest number of plants m^{-2}.

The maximum height (72.40 cm) of plant was observed from 150 kg N ha^{-1}. Plant height was progressively increased with the increase of nitrogen levels. The maximum plant height (72.40 cm) with 150 kg N ha^{-1} and second highest plant height (70.63 cm) were 15.59% and 12.77%, respectively greater than control plant height (62.63 cm). The tallest plants were produced with two weeding at 25 and 40 DAS which was followed by one weeding treatment. The plant height was found minimum with no weeding. Maximum plant height was found in plots having the combination of 150 kg N ha^{-1} and two weeding at 25 and 40 DAS (N_3W_2) which was statistically similar with those of N_3W_1 and N_3W_0. The shorter plant was found from the interaction of no nitrogen and no weeding (control).

The maximum number of branches per plant (5.75) was produced by the highest dose of nitrogen (150 kg ha^{-1}). It was 20.04% higher than the branches produced without nitrogen. In case of weeding, two weeding at 25 and 40 DAS gave the maximum number of branches per plant (4.92). One weeding treatment produced the second highest number of branches $plant^{-1}$ where no weeding (control) treatment gave the lowest number of branches $plant^{-1}$. The interaction between 150 kg N ha^{-1} and two hand weeding at 25 and 40 DAS (N_3W_2) produced the maximum number of branches $plant^{-1}$ (6.01).

Among the four different nitrogen doses, 120 kg N ha^{-1} gave the maximum number of siliquae per plant of rapeseed line. The second highest number of siliquae per plant was found from 150 kg N ha^{-1} where control (without N) produced the lowest number of siliquae in this study. The maximum number of siliquae per plant (65.72) was observed from two hand weeding which was at per with one weeding (64.97). The no weeding i.e. control treatment gave the lowest number of siliquae per plant (64.01). The interaction between 120 kg N ha^{-1} and two hand weeding i.e. N_2W_2

produced maximum number of siliquae plant^{-1} (72.70) which was 28.62% higher than control.

The highest length of siliqua (5.64 cm) was found from 150 kg N ha^{-1}. The second maximum length of siliqua was observed with the treatment 120 kg N ha^{-1} which was statistically identical with that of 90 kg N ha^{-1}. The control plot without any nitrogen produced the minimum length of siliqua. The maximum length of siliqua was observed from two weeding at 25 and 40 DAS where no weeding treatment produced the minimum length of siliqua. One weeding produced the second highest length of siliqua which was statistically different from others. The interaction between 150 kg N ha^{-1} and two weeding produced the maximum length of siliqua (6.34).

The nitrogen dose of 120 kg ha^{-1} produced the highest number of seeds per siliqua (19.91) which was followed by 150 kg N ha^{-1}. The lowest number of seeds per siliqua was found from control. Two hand weeding produced the maximum number of seeds per siliqua which was statistically identical with the number of seeds per siliqua found from one weeding. The highest number of seeds per siliqua was observed from N_2W_2 (120 kg N ha^{-1} and two hand weeding) which was at per with those of N_3W_1, N_3W_0 and N_3W_1.

Among the nitrogen levels, 120 kg N ha^{-1} produced the maximum weight of 1000-seed (3.16 g). The lowest seed weight was observed in the plots having no nitrogen. The maximum 1000-seed weight was observed from two hand weeding at 25 and 40 DAS which was statistically identical with the 1000-seed weight found from one weeding at 25 DAS. The maximum weight of 1000-seed was observed from the combination of 120 kg N ha^{-1} and two hand weeding (N_2W_2).

The treatment of 120 kg N ha^{-1} produced the significantly highest seed yield (2343.4 kg ha^{-1}) where control treatment (N_0) produced the lowest yield. The maximum seed yield ha^{-1} with 120 kg N ha^{-1} was 6.87%, 71.11% and 194.28% higher than the yield obtained from 150 kg, 90 kg and 0 kg N ha^{-1}, respectively. The seed yield with two weeding and one weeding were17.66 % and 8.64% higher than the yield obtained at control. The highest yield with N_2W_2 was 191.54% higher over the yield obtained at control (N_0W_0).

The application of 150 kg N ha^{-1} gave the highest stover yield (2850.30 kg ha^{-1}) which was statistically similar with 120 kg N ha^{-1} (2810.20 kg ha^{-1}). The lowest stover yield was observed in control plots (1223.40 kg ha^{-1}). The significantly highest stover yield was found from two hand weeding which was superior to one hand weeding and no weeding treatments. Stover yield which was found to be highest with the combination of 150 kg N ha^{-1} with two hand weeding (N_3W_2) was statistically at per with the yield obtained from N_3W_1 and N_2W_2. Stover yield was lowest with the treatment combination of N_0W_0 (control).

The maximum biological yield (5042.9 kg ha^{-1}) which was observed from 150 kg N ha^{-1} was statistically similar with the yield obtained from 120 kg N ha^{-1}. The lowest biological yield (2019.7 kg ha^{-1}) was found from no nitrogen application. The maximum biological yield (4311.5 kg ha^{-1}) was observed from two hand weeding at 25 and 40 DAS (W_2). The treatment N_3W_2 produced the maximum biological yield (5410.80 kg ha^{-1}) which was at per with N_3W_1 (5366.00 kg ha^{-1}) and N_2W_2 (5344.70 kg ha^{-1}). The treatment N_0W_0 produced the lowest biological yield (2052.20 kg ha^{-1}).

The significantly highest harvest index (45.47%) was observed with 120 kg N ha^{-1}. Treatments 150 kg N ha^{-1} and 90 kg N ha^{-1} showed the harvest indices of 43.48% and 30.43%, respectively. One weeding (W_1) gave the maximum harvest index (43.01%) which was statistically similar with two weeding (42.03%). Unweeded control treatment showed the lowest value of harvest index (41.86%). The highest harvest index (45.60%) was observed from the treatment combination of N_2W_2 which was followed by N_2W_1, N_3W_2, N_3W_1 and N_1W_2. The treatment N_0W_0 gave the lowest harvest index (35.39%).

In this study, the oil content (%) was increased up to 120 kg N ha^{-1} and then decreased. The significantly higher oil content was observed with 120 kg N ha^{-1} (43.33%) and then the second highest oil content was found from 150 kg N ha^{-1}. The lowest oil content was found in unweeded control (40.08%). The highest oil content was observed with two hand weeding and the lowest oil content was found in unweeded control. The highest oil content (43.5%) was observed with the treatment combination of N_2W_2 which was followed by N_3W_2, N_2W_1 and N_3W_1. Oil content was found to be lowest with the treatment N_0W_0.

The effect of nitrogen on oil yield of rapeseed was significantly increased up to 120 kg N ha^{-1}. The significantly highest oil yield (771.00 kg ha^{-1}) was observed with two hand weeding (W_2) where unweeded treatment (W_0) produced the lowest oil yield of 653.2 kg ha^{-1}. The highest oil yield of 1057.50 kg ha^{-1} was observed with the treatment N_2W_2 where N_0W_0 produced the lowest oil yield (333.90 kg ha^{-1}). The highest oil yield was also statistically similar with those of N_3W_2, N_3W_1 and N_2W_1.

From correlation and regression study it was found that there was a significant correlation between the yield attributes and seed yield $plant^{-1}$ of rapeseed. Number of branches $plant^{-1}$, number of siliqua $plant^{-1}$, number of seed $plant^{-1}$, 1000-seed weight had a significant correlation with seed yield $plant^{-1}$ with the r values of 0.91, 0.97, 0.88 and 0.96, respectively. The relationship between the yield attributes and yield was highly significant.

By summarizing the above discussion, the conclusion may be drawn as follows:

i) Nitrogen levels and number of weeding significantly influenced plants m^{-2}, plant height, branches $plant^{-1}$, siliquae $plant^{-1}$, length of siliqua, seeds $siliqua^{-1}$, 1000-seed weight, seed yield, stover yield, biological yield, harvest index, oil content and oil yield. Only oil content remained statistically similar with different weeding treatment.

ii) Most of the yield contributing characters including seed yield responded significantly with the application of 120 kg N ha^{-1}. Hence, this level seems to be adequate for higher seed yield. But the number of plants m^{-2}, plant height, branches $plant^{-1}$ were responded best with 150 kg N ha^{-1}.

iii) The rapeseed line showed a positive response to weed management with respect to seed yield and oil yield. Most of the yield contributing characters and seed yield were significantly enhanced with two hand weeding at 25 and 40 DAS.

iv) The combination of 150 kg N ha^{-1} and two hand weeding at 25 and 40 DAS produced the maximum plants m^{-2}, plant height, branches $plant^{-1}$. But most of the yield contributing characters, seed yield, stover yield, harvest index, oil content and oil yield were mostly responded to the combination of 120 kg N ha^{-1} and two hand weeding. In each parameter studied, the control combinations showed poor performance.

The study will now provide guidelines about nitrogen levels and number of weeding required for the c.v. SAU Sarisha-1 for optimum yield harvest. However, further field trial may be taken in different agroecological zones in relation to the physiological and biochemical aspects of this line to reestablish the findings obtained in this study.

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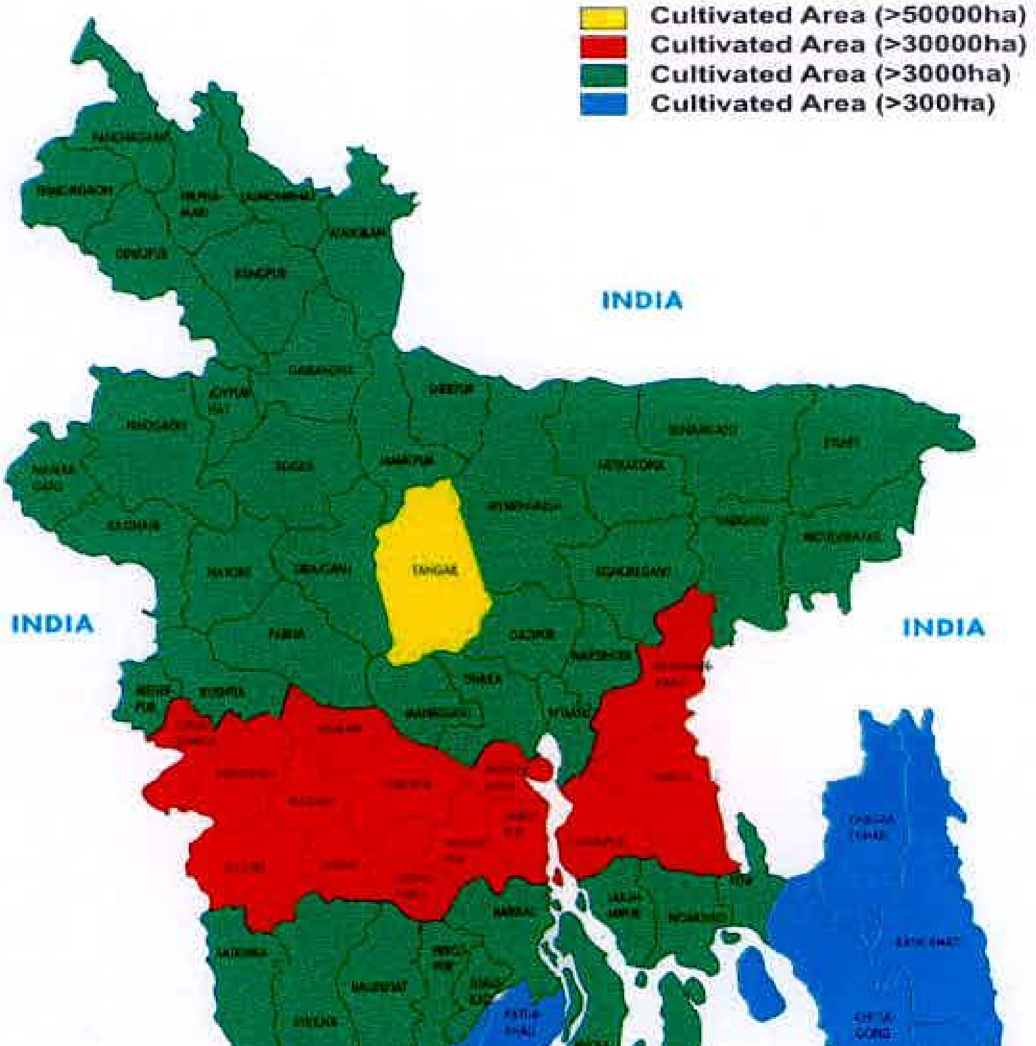
Appendices

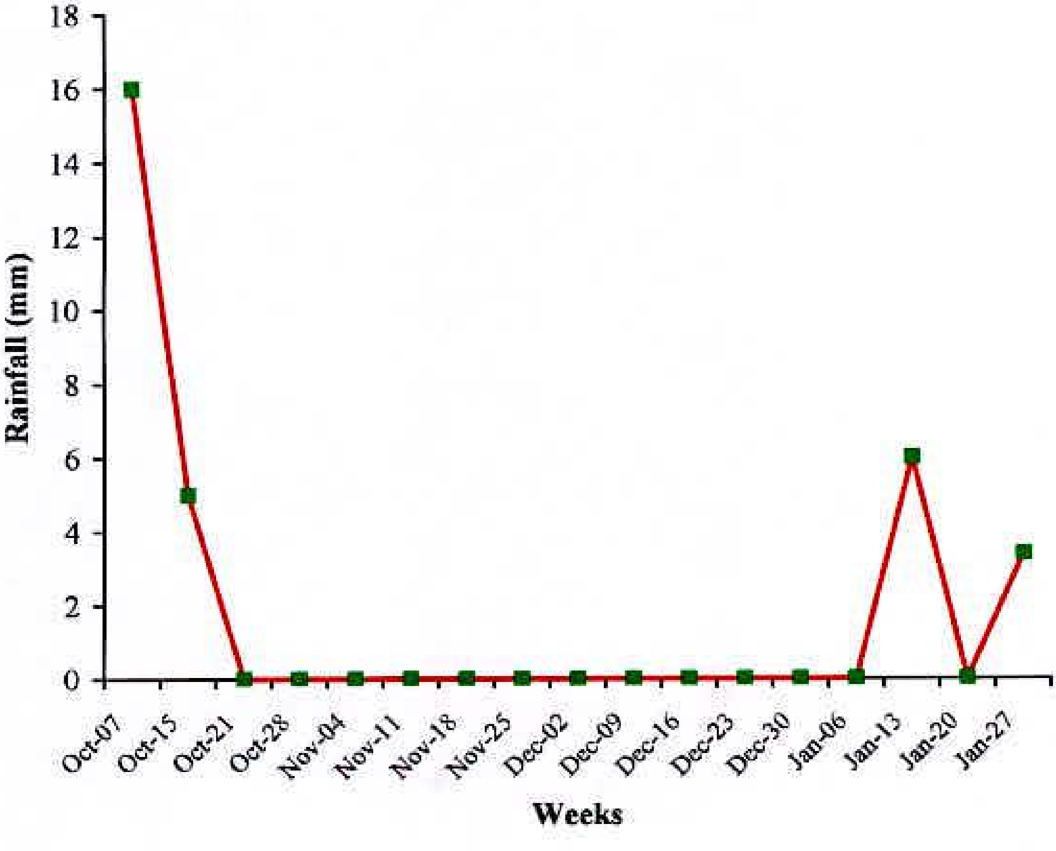
APPENDICES

Appendix I. Major rapeseed and mustard growing areas (ha) in Bangladesh (1992-1997)



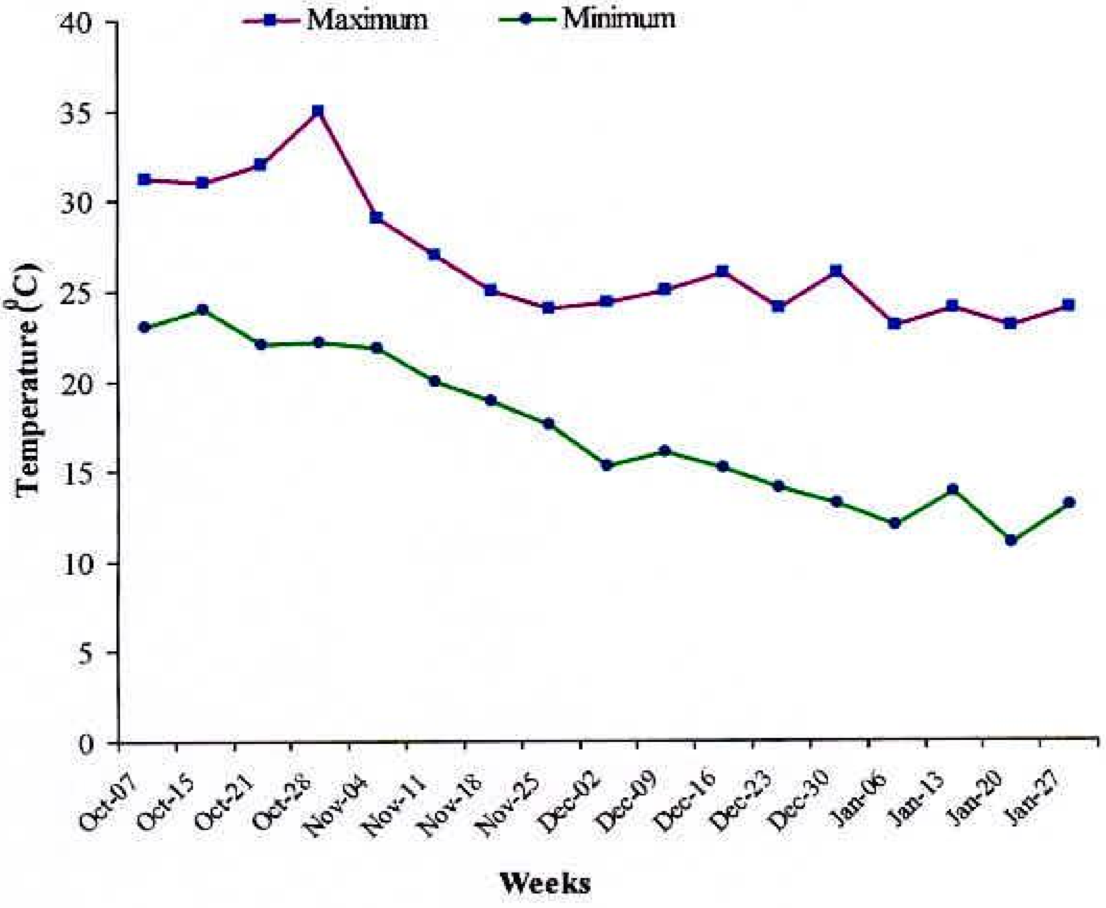
Source: BARI

Appendix II. Weekly average total rainfall during the study (October, 2005 to January, 2006)



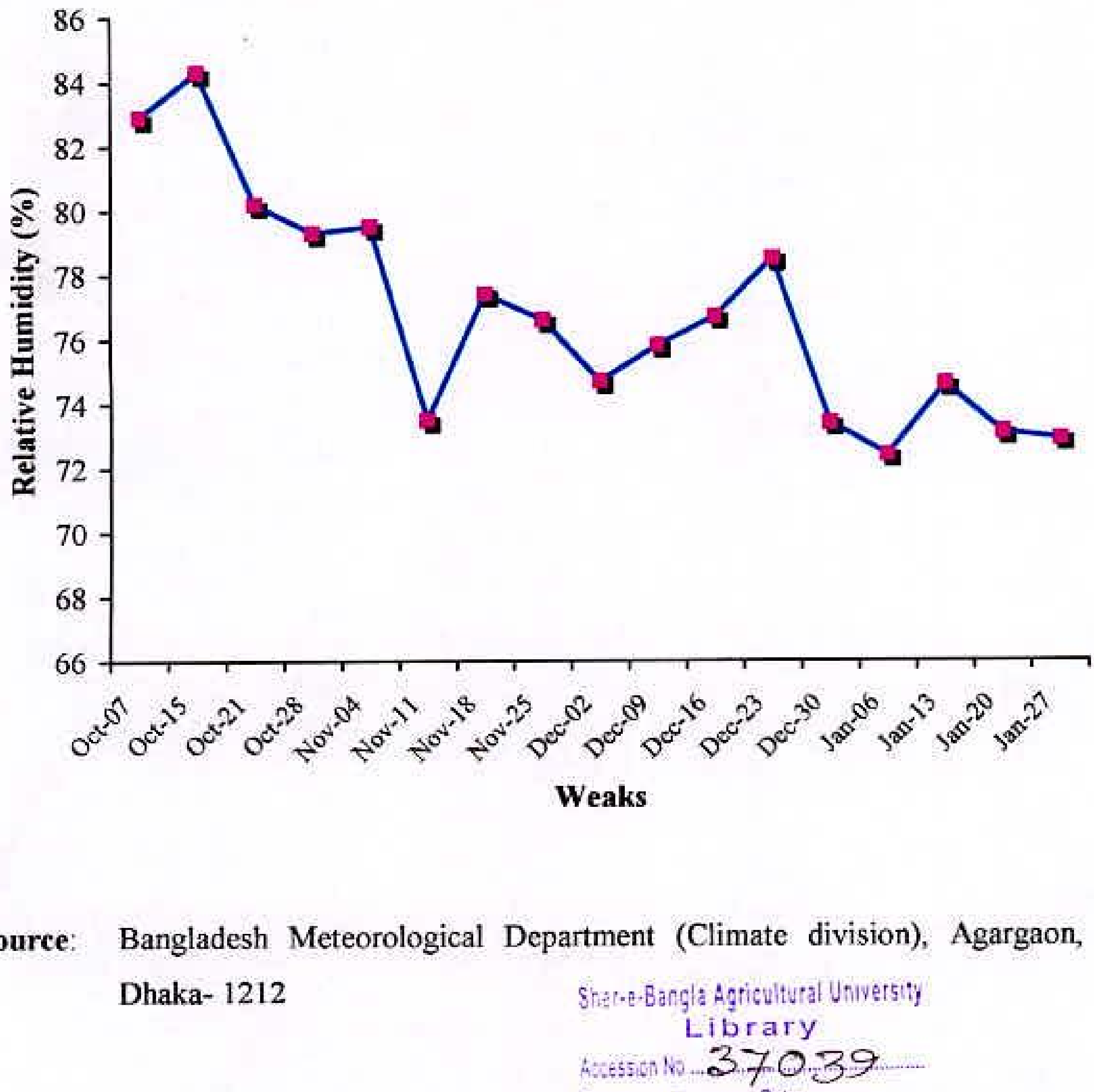
Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka- 1212

Appendix III. Weekly average air temperature during the study (October, 2005 to January, 2006)



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

Appendix IV. **Weekly average relative humidity during the study (October, 2005 to January, 2006)**



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