EFFECT OF SOWING TIMES AND MUSTARD VARIETIES ON THE INCIDENCE OF APHID

MD. ASHIKUR RAHMAN

DEPARTMENT OF ENTOMOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SHER-E-BANGLA NAGAR, DHAKA -1207

DECEMBER, 2014

EFFECT OF SOWING TIMES AND MUSTARD VARIETIES ON THE INCIDENCE OF APHID

MD. ASHIKUR RAHMAN

Registration No. 08-03027

A Thesis

submitted to
the Department of Entomology, Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)
IN
ENTOMOLOGY

SEMESTER: JULY-DECEMBER, 2014

APPROVED BY

……	…….
Prof. Dr. Md. Razzab Ali	**Dr. Mohammed Sakhawat Hossain**
Supervisor	**Co-Supervisor**

……..
Dr. Mohammed Sakhawat Hossain
Chairman
Examination Committee

DEPARTMENT OF ENTOMOLOGY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

*This is to certify that the thesis entitled "**EFFECT OF SOWING TIMES AND MUSTARD VARIETIES ON THE INCIDENCE OF APHID**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN ENTOMOLOGY,** embodies the result of a piece of bona fide research work carried out by **MD. ASHIKUR RAHMAN**, Registration no. **08-03027** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2014
Dhaka, Bangladesh

Prof. Dr. Md. Razzab Ali
Supervisor
Department of Entomology
SAU, Dhaka

ACKNOWLEDGEMENT

All praises are due to the Almighty Allah, the great, the gracious, merciful and supreme ruler of the universe to complete the research work and thesis successfully for the degree of Master of Science (MS) in Entomology.

The author expresses the deepest sense of gratitude, sincere appreciation and heartfelt indebtedness to his reverend research supervisor Prof. Dr. Md. Razzab Ali, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, innovative suggestions, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of this manuscript.

The author also expresses his sincere appreciation, profound sense, respect and immense indebtedness to his respected co-supervisor Dr. Mohammed Sakhawat Hossain, Associate Professor of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207, for extending his generous help, scholastic guidance, constructive criticism, continuous inspiration and valuable suggestions during the research work and preparation of the manuscript of the thesis.

The author would like to express his deepest respect and boundless gratitude to all respected teachers of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207 for their sympathetic co-operation and inspirations throughout the course of this study and research work.

The author extends his heartiest thanks and gratefulness to many other well wishers for their inspiration, encouragement, help and active co-operation for carrying out the present study.

He would like to express his last but not least profound gratitude to his beloved parents who sacrificed a piece of time for author during the study period. He is grateful to all of his relatives for their inspiration, blessing and encouragement that opened the gate of her higher studies in his life.

Dated: December, 2014 **The Author**

SAU, Dhaka

EFFECT OF SOWING TIMES AND MUSTARD VARIETIES ON THE INCIDENEC OF APHID

BY

MD. ASHIKUR RAHMAN

ABSTRACT

The study on the effect of sowing times and varieties on the incidence of mustard aphid was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the winter season from November, 2013 to February, 2014. The experiment was laid out in two-factorial randomized complete block design with three replications. Eight mustard varieties such as V_1 (Tori-7), V_2 (BARI Sharisha-6), V_3 (BARI Sharisha-9), V_4 (BARI Sharisha-11), V_5 (BARI Sharisha-13), V_6 (BARI Sharisha-14), V_7 (BARI Sharisha-15) and V_8 (BARI Sharisha-16) sown in three sowing times considering 7 days interval such as S_1 (9 November, 2013), S_2 (16 November, 2013) and S_3 (23 November, 2013) were studied in terms of aphid infestation on plants, inflorescence and pods aiming to find out the tolerant variety(ies) against aphid as well as effective sowing time(s) to escape aphid infestation. Out of eight mustard varieties, Tori-7 was found as the most preferred host for aphid infestation followed by BARI Sharisha-9, where as BARI Sharisha-13 performed as least preferred varieties in terms of aphid infestation on plants, inflorescence, and siliqua. On the other hand, out of three sowing times, late sowing (23 November) was found as the most suitable for aphid infestation followed by 16 November, where as the earliest sowing time (9 November) was found as the worst for aphid infestation on mustard whatever the variety was cultivated. The most aphid susceptible variety Tori-7 produced the lowest grain yield per hectare followed by BARI Sharisha-9. Conversely, the least aphid susceptible variety BARI Sharisha-13 produced highest grain yield per hectare. From the combined effect, the study revealed that the BARI Sharisha-13 manifested the lowest aphid infestation and produced highest yield when sown at early season (9 November). Conversely, Tori-7 manifested the highest aphid infestation and produced lowest grain yield when sown in late season (23 November).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Mustard or rapeseed is one of the most important and widely grown oilseed crops of Bangladesh. It is locally known as *sharisha*,a popular and most common oilseed crop in Bangladesh and in other tropical and sub-tropical parts of the world. It belongs to genus *Brassica* under the family Cruciferae and has got several cultivated species, viz. *Bassicacampestris* L., *Brassica juncea* L. and *Brassica napus* L. etc. It is produced mainly in the rabi season. Out of total cropped area of 13.53 million hectares in Bangladesh, oil crops occupy only 0.561 million hectares which is about 4.2 % of the total cropped area and contribute to about 1.6% of total grain production of the country (Anon., 2012). Rapeseed-mustard occupies only 0.336 million hectors, (60 %) among oil cropped area (Wahhab*et al.*, 2012). Among mustard, Tori-7 (*Brassica campestris*)is grown in 75% of the area and Rai group (*Brassica juncea*) covers about 25 % of the area. Recently rapeseed (*Bassicanapus*) is being introduced (Rahman, 2012). Mustard is a popular nutritious oil seed crop. The rapeseed is a rich source of oil and protein. It contain more than 40% oil. Mustard oil is mainly used for cooking purposes and also as hair and body oil in rural areas. It also serves as an important raw material for industrial use such as in soaps, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals etc. Oil cake is important animal feed. After threshing, pods and plants are used as fuel. Leaves of the plant are popular vegetable in our country. Sticks of high yielding varieties are good fuel (Rahman, 2012).

The analysis of productivity trend reveals that mustard yield in Bangladesh has increased from 672 kg ha^{-1} to 757 kg ha^{-1} with the annual growth rate of 1.26 % (Rahman, 2012),which is alarmingly poor compared to that of advanced countries like Algeria, Germany, France, UK and Poland, where the productionsare 6667 kg ha^{-1}, 3507 kg ha^{-1}, 3264 kg ha^{-1}, 3076 kg ha^{-1} and 2076 kg ha^{-1},respectively (FAO, 2011).

The major reasons for low yield of mustard in our country are due to lack of high yielding variety, inappropriate sowing time and proper insect management etc.The best growth of mustard occurs above 12^{o}C and below 25^{o}C (Wahhab*et al.*, 2012). The

weather of Bangladesh allows very short sowing period for mustard. The winter in Bangladesh is not long,where temperature starts rising from the month of February. So, mustard harvesting should be complete by middle of February, otherwise the crop faces high temperature and yield becomes low. So, sowing at proper time allows sufficient growth and development of a crop to obtain satisfactory yield. Different sowing dates provide variable environmental conditions with the same location for the growth and development of crop yield stability (Pandey*et al.*, 1981). Sowing times must have significant effect on the yield and yield components of mustard (Saran and Giri, 1987). The sowing date has a considerable influence on growth and development of plant as well as on seed yield of mustard (Rahman*et al.*, 1988). Early sowing may result in vigorous growth and less resistance to cold during winter while late sowing may result in stunted growth and crop may be attacked with disease and insect pests leading to reduction in seed yield (Kaul and Das, 1986). Seed yield of mustard declined gradually by 11.7, 21.5, 43.4 and 62.9 % respectively, for each week delay after November 1 sowing (Rahman*et al.*, 1993). Yield reduction due to late sowing is common occurrence owing to low level of dry matter accumulation accompanied by pod abortion and poor seed set.

One of the major constraints that responsible for low yield is mustard aphid which is considered as key factor in reducing mustard production and sometime it is so severe that may cause yield loss upto 90%.Bakhetia (1983) have listed more than three dozens of insect pests, associated with various phenological stages of this crop. Among them *Lipaphiserysimi*, commonly known as mustard aphid is most destructive in Bangladesh (Alam*et al*., 1964; Ahmed *et al.*, 1977; Kabir, 1987; Begum, 1988; Shahjahan, 1994; Husain and Shahjahan, 1997). It belongs to the family Aphididae of the order Homoptera.Both nymphs and adults of mustard aphid, *L.erysimi*cause damage to mustard plants from vegetative to siliqua maturity stage (Verma*et al.*, 2005).The nymphs and adults of this pestssuck sap from twigs, siliqua, flower buds, flower and leaves of the plants.Maximum damage caused by aphid at pod formation stage. But siliqua is the most suitable part for development of this pest (Tripathi*et al*., 1986). At heavy infestation large number of aphid congregate under side of leaves causing curling and yellowing. Poor pods formation and stunted growth is due to large number of aphidson the whole plant. As a result both the production and quality of mustard seed is poor with low market price.

The environmental factors such as temperature, rainfall and relative humidity, usually influence the abundance of insect greatly. Depending on the prevailing environmental conditions the aphid population increase in huge numbers. Information on the seasonal prevalence of insect pests, particularly mustard aphid in relation to weather factors is scanty. The early sown crop almost escaped the aphid attacks in all the growth stages of the crop and resulted higher yield compare to late sown crop. However, some varieties gave better yield compare to other irrespective of sowing time and showed substantial level of resistance against mustard aphid. Thus the study was carried out to evaluate the effect of sowing times and different mustard varieties available in Bangladesh on the incidence of mustard aphid, *L.erysimi*so that better management strategy can be formulated.

In view of the limited information on the problems mentioned above, a field study was conducted with following objectives:

i) To evaluate the sowing times on the incidence of aphid population infesting mustard;
ii) To evaluated different mustard varieties against aphid infestation;
iii) To study on the infestation level of mustard aphidon three sowing times of eight mustard varieties.

CHAPTER II

REVIEW OF LITERATURE

Mustard aphid, *Lipaphiserysimi* (Kalt.) is an important insect pest of cruciferous plants. Good number of works has been done specially on nature of damage, seasonal abundance, population dynamics and control measures. Studies are also available regarding its origin, biology and distribution. Various aspects of biology and life history parameters are related to each other and the relevant literatures on these studies are reviewed below on different aspects.

2.1 General review of mustard aphid

2.1.1 Geographical distribution

The mustard aphid, *Lipaphiserysimi* (Kalt.) is distributed worldwide (Martin, 1983; Pradhan, 1994 and Eastop, 1961). It is found in all tropical and subtropical countries (Schmutterer, 1978) and is recognized as a worldwide serious cruciferous pest (Atwal*et al.*, 1976).

2.1.2 Host range

In temperate climate, many aphid species are host alternating and have a primary host, which is usually a woody plant and secondary hosts which are generally herbaceous (Dixon, 1985 and Kawada, 1987). *Lipaphiserysimi* is well known as a serious pest of mustard, cabbage, cauliflower, turnip, kohlrabi, radush, rai, toria, broccoli etc. and minor pest of bean, beet, spinach, pea celery, onion, stock, soybean, cucumber and potato (Schmutterer, 1978 and Eastop, 1961). Ghosh (1985) reported the host plant range covering many families (Muller and Scholl, 1958; Schmutterer, 1978 and Hill, 1983).

2.1.3 Taxonomic position of mustard aphid

Taxonomic position of the mustard aphid, *Lipaphiserysimi* (Kalt.) is given below:

Phylum: Arthropoda
Sub-phylum: Mandibulata
Class: Insecta
Sub-class: Apterygota
Order: Homoptera
Family: Aphididae
Sub-family: Aphidinae
Genus: *Lipaphis*
Species: *Lipaphis erysimi*

2.1.4. Biology and life history strategies

Eastop (1961) and Martin (1983) described the taxonomic features of apterae and alate of *Lipaphiserysimi* (Kalt.). It is a short bodied, yellowish and green or greenish colored species measuring 2-2.5 mm length when they are fully grown. The adults may be wingless (Apterae) or winged (alate) with two pairs of hyaline wings. The fifth abdominal segment bears a pair of cornicles. The winged adults usually have black body markings and blackish head.

Phadke (1992) studied the life table and growth rate of mustard aphid, *Lipaphiserysimi* (Kalt.) on different varieties of *Brassica* app. and reported the highest net reproductive rate of 119.38 and lower one of 86.12. Amjad and Peters (1992) studied the fecundity, survival rate and days to maturity of *L. erysimi* (Kalt.) and found fewer days to mature in *B. campestris var. toria* (7.9 days) than in *B. carinata* and *B. junacea*. Fecundity was significantly higher *B. carinata* and *B. juncea*. The intrinsic rate of population increase was significantly higher in *B. campestris* than other host plants, while it was the lowest in *B. carinata*. The survival of nymphs was significantly higher in *B. campestris* (95 %) and the lower in *B. juncea* (57 %).

Mondal*et al.* (1992) studied the biology of *L. erysimi* (Kalt) in the laboratory on young leaf of different host plant. They reported that the mean nymphal period were 10.67±0.38, 10.92±0.8, 9.67±0.23 and 9.50±2.05 days on *B. juncea* (china cabbage), *B. juncea* (mustard plant), *Raphanussativus* (radish) and *Solanummelongena* (brinjal), respectively.

Shahjahan (1994) studied the adult longevity of *L. erysimi* (Kalt) on 10 different varieties of mustard. He found that adult longevity on different varieties varied from 8.07-10.7 days. The duration of adult longevity was the highest (10.7 days) on Nap-3 and the lowest (8.7 days) on Tori-7.

Vekaria and Patel (1998) reported the total number of generations completed by the mustard aphid between January and March. The aphid completed 11 overlapping generations at 21.9°C and 52 % RH during the first season and 8 generation at 23.7°Cand 57 % RH during the second season. The average duration of each generation was 6.04

days during 1996 and 1.15 days during 1997. The mean nymphal period was 6.84±0.8 and 6.07±0.65 days and adult longevity was 8.20±1.12 and 8.62±1.05 days during which time and average of 26.92±5.32 and 37.66±8.93 nymphs developed, respectively, in the first and second set of insects under observations.

Kuo (1999) studied that percentage of alate formation of the turnip aphid was investigated at different densities under 5 various constant temperature and photoperiods. The result revealed that interaction between temperature and rearing density, but no effect of photoperiod was found. When nymphs were reared at densities of 1.5 and 10 nymphus/tube, alate was formed at all temperature tested and the highest percentage of alate formation was 7.7, 38.3 and 63.3 %, respectively. When rearing density of nymph increased at various constant temperature, the percentage of alate significantly increased. By analyzing the occurrence of alate with multiple factor regression, it was found that nymph rearing density and temperature were the major extrinsic factors for alate formation. High (30°C) and low (10°C) temperature suppressed alate formation. The optimal temperature for the occurrence alate of *L. erysimi* ranged from 15 to 20°C.

Vekaria and Patel (1998) conducted field studies during the rabi season of 1995-96 in Gujarat, India, to determine the biology of *L. erysimi* on three Indian mustard cultivars (GM-1, Varura and PM-67). The nymphal period was shortest (5.88 ±0.67 days) on PM-67 and longest (6.58 ±0.65 days) on GM-1. Adult longevity and total life span were shortest on GM-1 (8.710).

Roy *et al.* (2002) reported that the embryonic and population development of *L. erysimi* on Indian mustard cv. Daulat were investigated in Gazipur, Bangladesh. Embryonic development at the siliqua development stage less than 19.3°Cfollowed and exponential pattern. At this stage, the development of an embryo into an offspring and of a newly born nymph into an adult required 7 days. The average size of the largest embryo was 0.104 and 0.06 mm^3 for the apterae and alate forms of the adult. The percentage of alatiod nymphs and aphid-infested plants, two factors that were positively correlated, increased as the season progressed. Almost 50% of the total nymphs were alatoid the end of the season.

Schmutterer (1978) also reported that the pest breeds only parthenogenetically and has no sexual forms in tropical countries. Although Ghosh (1985) reported that some sexual forms at the end of the season.Atwal*et al.* (1976) reported that parthenogenetic reproduction of this species gave birth to 16-133 nymphs which became full grown in 7-10 days.

Sachan and Bansal (1975) studied the biology and performance of *L. erysimi* on different host plant, viz. cabbage, mustard, cauliflower and radish. They found that lowest developmental period in radish (9.02 days) and highest in cabbage (11.3 days). The lowest period of reproduction (22.7 days) was recorded in cabbage and the shortest in radish (15.2 days). The average number of offspring lay on different host plants were in the decreased order of mustard (87.65), cauliflower (81.80) and radish (70.60). They also recorded the longevity of apterae as 37.90, 32.70, 35.80 and 28.00 days in cabbage, mustard, cauliflower and radish, respectively.

Schmutterer (1978) reported that the nymphs did undergo four nymphal stages and become adult in about 6 to 10 days. The length of adult stages was 13-15 days. The duration of 1^{st}, 2^{nd}, 3^{rd} and 4^{th}instars were about 2-4, 2-4, 3-4 and 3-4 days, respectively. On an average 100-200 nymphs were deposited from a single aptera.

Bassvaraju*et al.* (1994) observed in laboratory studies that the life cycle was similar for all three aphid forms with slight differences. There was a longer post reproductive period and longevity for aphids derived formalate parents (7.75-8.37 and 30-35 days, respectively) and the total number of nymphs was greater ranging from apterous parents. The post-reproductive and longevity periods of alate aphid were 0.37-1.12 and 14.75-18.12 days, respectively. The total numbers of nymphs laid by late aphids were also ranging from 39-71.

Kundu*et al.* (1997) studied the short-term reproductive effort of the species in terms of number of well-developed embryos in adult aptarae and recorded significantly the highest adult weight and number of developed embryos in Dcember. Their study reflected to the host plant availability. They also observed a significant positive relationship between body weights with the number of weel-developed embryo's.

Roy and Baral (2002) studied the embryonic and population development of *L. erymisi* on mustard. They reported that growth of the embryo occur exponentially where the period for full development to be laid as an offspring as well as for a newly born nymph to become adult took seven days under daily mean field temperature of 19.3°Cat siliqua development stage. They also reported that size of the largest developed embryo was always significantly bigger in apterae (0.104 mm^3) than alate (0.063 mm^3).

Kundu*et al.* (2002) studied the seasonal trends in the reproductive potential of *L. erymisi* on mustard. They recorded the best reproduction and its early stage of development during 2nd fortnight of January. In both alate and apterae, they found a significant positive relationship between adult weight with that of total and well developed embryos.

Nasir*et al.* (1998) studied on the population dynamics of mustard aphid in relation to abiotic factors. Adults appeared on the crop in the last week of February, the population peaked in the third week of March and aphids disappeared by the third week of April pest population were positively correlated with the average daily temperature, but negatively correlation with relative humidity and rainfall.

Sinha*et al.* (1990) observed the duration of the different stage in the life cycle of *L. erysimi* under ambient temperature and humidity from December to March (18.7 ± 7.9°C and 62.4 ± 11.0 RH). The nymphal period showed a positive correlation with ambient period and longevity were negatively correlated with ambient temperature. The fecundity of the aphid was positively correlated with ambient relative humidity and negatively with temperature. The fecundity of offspring from apterous aphids (40.0/ female) was greater than in those from alate aphids (32.6/female). The longest duration of total life span (39.0 days for apterae and 43.7 days for alate) occurred in January and the shortest (24.0 days foe apterae and 29.7 days for alate) in March to April.

Biswas and Das (2000) observed the relation to weather parameters on mustard aphid. They observed that the aphid population build up was noticed during January-February reaching the peak on the 8th February in both 1997 (98.26 aphid plant^{-1}) and 1998 (76.22 aphid plant^{-1}). They ambient sunshine (5.76-8.50 hrs.) and the maximum temperature (23.66°C to 25.37°C) during January-February appeared to be the conductive factors for

aphid multiplication. Relative humidity (RH) ranging from 62.00 to 74.28% during January-February was congenial for aphid population build recommended variety Agrani, Safal, Sonali and Tori-7 for their resistance to mustard aphid. The result revealed that the mustard BINA-2 had significantly lowest aphid infestation at Mymensingh and Satkhira among the tested mustard/variety.

Singh and Lal (1999) studied on *Lipaphiserysimi* (Kalt.) infestation in *B. juncea* (Indian mustard) crops during two successive crop seasons (25th December 1989 to 4th March 1990 and 1st January to 13th March) in India. They found that *L. erysimi* (Kalt.) occurred from the last week of December to the first week of March in 1989 and the first week of January to the second week of March in 1990. The peak infestation mustard aphid (415.45 per 10 cm terminal shoot per plant) was recorded on 13th February in the first year while the maximum infestation (471.10 per 10 cm terminal shoot per plant) was recorded on 6th February.

Islam (1991) carried out an experiment at BARI, Joydebpur, during Rabi season, 1990-1991 to found out the effect to time of sowing on the abundance of *L. erysimi* on mustard and extent of its production. He investigated that the highest percent of infestation was found from 21th January to 28th January, 1991 and after than the infestation rate decreases gradually.

Schmutterer (1978) reported that the infestation of this pest in India starts by November to December and lasts up to March, reaching a peak at the end of December to end of the February at temperature 11-14°C and 60-80% RH. He also reported that heavy rainfall causes sharp decline in the population. On an average 5-6 generations are recorded per year in the plains of India (Schmutterer, 1978, Ghosh, 1985).

Study of Ahuja (1990) revealed the appearance of *Lipaphiserysimi* (Kalt.) between late December to early January and the population reaching a peak between 26 January to 26 February in Rajasthan, India. He found a negative correlation of the aphid population with maximum temperature and sunshine but positively with that of humidity.

Kabir and Khan (1980) reported that low temperature and reduction of humidity apparently caused the heavy build up of the population if mustard aphid whose infestation was severe from the January to the middle February.

Sinha*et al.* (1989) observed the appearance of *L. erysimi* in the third week of December with an increasing pattern in January/February which reached to a pack in the mid the February in Bihar, India. Temperature and humidity were found important by them for aphid from the positive and negative influence of humidity and temperature on aphid population, however, Jaglan*et al.* (1988) found no influence of these two components of weather on *L. erysimi* population but they found rainfall to cause a significant and sudden decline of it. They reported the maximum population between the end of February and end of March in Haryana, India.

Roy (1975) reported that the population of aphid was independent of the impact of temperature and relative humidity but rain had profound effect on the population in West Bengal, India.

Ram and Gupta (1987) observed that the development of the aphid population on mustard was favored by maximum and minimum temperature of 21.4-22.8°C and 5.9-7.6°C respectively and relative humidity of 80.2-83.8% and 31.2-40.9%. Mild showers (about 2 mm) and cloudy weather caused an increase in aphid population but heavy showers (about 10 mm) dislodged the aphid and the subsequent decline in temperature reduced their rate of increase. The population dynamics of mustard aphid in relation to biotic factor in rape-seed in Pakistan revealed the appearance of this pest in the last week of February reaching the pack in the third week of March and disappeared by the third week of Aphid (Nasir*et al.*, 1998). They found the aphid population to be positively correlated with the average daily temperature but negative correlated with humidity and rainfall.

Uttam*et al.* (1993) reported that infestation of mustard by *Lipaphiserysimi* starts when average temperature varied from 7.5 to 15^{o}C with RH 62.5-93.5%.

2.2 Effect of sowing time on aphid population

Patel *et al.* (2004) observed that Indian mustard seeds were sown on November 8, November 18, November 28, December 8 and December 18 in a field experiment conducted in India during winter of 1995-1998. The yield of Indian mustard decreased with delayed sowing. The highest seed yield (1409 kg ha^{-1}) was recorded with November 8 sowing. The critical period of mustard experiment to aphids was during the flowering stage of the crop. The aphid population increased in December.

Sihag*et al.* (2003) mentioned that, the crop sown on November 15 recorded the highest seed yield (1164.40 kg ha^{-1}) but it is did not differ significantly from that of November 23 sowing (1001.90 kg ha^{-1}). Inferior yield was obtained from December 7 (612.00 kg ha^{-1}) sowing which was identical to that from November 30 (700.60 kg ha^{-1}) due to the high temperature at reproductive stage.

Angrej*et al.* (2002) found that, early sowing was recorded higher value for the different plant height.

Shivani*et al.* (2002) experiment sowing on September 25 and October 5 recorded significantly higher number of siliqua per plants. Number of siliqua per plants was significantly influenced by sowing time.

Buttar and Aulakh (1999) found pod per plants were higher in October 25 (1^{st} date) sowing. This was due to the fact that under earlier sown crop, the temperature and other climatological parameters palyed a major role for growth and yield attributes.

Mondal*et al.* (1999) stated that the highest number of siliqua per plants was found in the plant of third planting (1 November). The number of siliqua was less in the last two planting and first planting.

Shahidullah*et al.* (1997) reported that number of seeds pod was decreased with delay in sowing among the three sowing dates on October 27, November 6 and November 16.

Mondal and Islam (1993) found that the longest plants were found in the plots of November 1 sowing which was followed by November 15 and October 15 sowing. The

shortest plant height was found in the plots of December 1 sowing. In case of late sowing in December 1 plants faced higher temperature during later stages of growth, so the plants were shorter than the other sowing dates.

Date of planting has direct effect on plant height. Sran and Giri (1987) reported that plant height decreased gradually (51-140) with delaying the sowing by one month (October 15 to November 15).

Mohammed *et al.* (1984) observed similar results at Aligarh (India). A number of authors also reported that the seedling of mustard on October produced the highest plant height (Kandil, 1983; Ansari *et al.*, 1990).

Kalra*et al.* (1985) and Scott *et al.* (1973) also observed that delayed sowing decreased seeds per pod and 1000 seed weight in several other trials.

Seeds per pod in mustard is directly affected by sowing date (Beech and Norman, 1964. Ghosh and Chatterjee (1988) stated that one month delay in sowing decreased seeds per pod by 23%.

2.3 Susceptibility of mustard varieties to aphid

Many scientists have done enormous research works in many parts of the world for the development of resistant varieties of mustard to aphid.

Prasad (2003) screened that fifty-three varieties/cultivars belonging to different species of oilseed *Brassica* and for resistance to the aphid *L. erysimi* none was free from aphid infestation *B. juncea, B. campestris and B. tournefortii* lines. Some of the lines died due to severe aphid infestation.

Singh *et al.* (2000) evaluated that the nine parents and their 36 F_1 hybrids from a diallele cross involving 5 genotypes, none of the parent lines or their hybrids were observed to be completely free from mustard aphid attack percent plant infestation, siliqua per unit length on main stem.

Vekaria and Patel (2003) evaluated that the relative resistance of forty promising *Brassica* and allied genotypes against the mustard aphid, *Lipaphiserysimi* (Kalt.). None

of the genotypes tested was found to be immune, however, five genotypes *B. napus, B. carinata, Eruca sativa, E. vesicaria* and *B. tournefortii* were found to be resistant to the aphid. Mustard genotypes belonging to the *B. campestris* group were found to be more susceptible to the aphid than those of *B. juncea*.

Samdur*et al.* (1997) reported that the effect of 7 environmental factors on *L. erysimi* infestation in 75 germplasm lines of *B. juncea*. The mean aphid infestation index (MAII) was significantly and negatively correlated with maximum temperature, evaporation, sunshine and wind velocity and was significantly and positively correlated with maximum RH for *B. juncea* sown in the first week only. It is concluded that optimum weather conditions are necessary for the effective screening of *B. juncea* resistance against *L. erysimi* infestation.

Lal*et al.* (1997) reported the results of the relative performance of 83 *Brassica*gerplasms against the mustard aphid, *Lipaphiserysimi* (Kalt.), Screening revealed that two germplasms (B-85 glossy and RW-White glossy) were highly resistant, 13 germplasms were resistant and 21 were moderately resistant. Forty-two germplasms were rated as susceptible and 5 as highly susceptible to *L. erysimi*.

Rai*et al.* (1995) screened that out of 18 different entries of toria, sarson and rai [Indian mustard] cvs. PYS-843, PR-8801 and PYS-841 be the most resistant to *Lipaphiserysimi* and gave the highest yields.

Kher and Rataul (1992a) conducted that results are presented of field experiments, conducted in Ludhiana, India in 1987-1989 to assess the resistance of 7 strains of *Brassica campestris*, 7 strains of *B. juncea* [Indian mustard] and 5 strains of *B. napus* [rape] to *Lipaphiserysimi*.

Kher and Rataul (1992b) screened that nineteen strains of rape were tested in the field in Punjab, India, in 1987-1989 for resistance to *Lipaphiserysimi*. All strains of *Brassica napus* except Regent and Gullivar to be relatively resistant. Strains of *B. campestris* supported very high aphid populations and were considered highly susceptible. Strains of *B. juncea* were moderately resistant.

Verma*et al.* (2005) conducted that a field experiment in India to screen 16 mustard cultivars (15 *B. juncea* and One *B. nigra*) for their resistance to the mustard aphid, *Lipapgiserysimi* (Kalt.). Aphid infestation index (All, 0-5 scale) was calculated at full flowering and full pod formation stages. Banarsi, Rai and Rohini were considered highly resistant to aphid infestation, will All of 0.56-0.67 and 0.79-0.69 in 2001-2002 and 2002-2003, respectively. RK-819, Krishna, RK-9304, RGN-19, RK-9801, RK-90, Basanti, SGB-51, Urvashi and MLN-157 were moderately resistant, with All of 2.1-2.95 in both years. Varuna, Vardan and UPN-9 were susceptible with All of 3.8-3.3, 3.8-3.0, 3.4-3.0 and 3.3-3.0 in both years.

Balwant*et al.* (2004) evaluated that *Eruca sativa* [*E. vesicaria*], *Diplotaxissiifolia, B. tournefortii, B. campestris* and lines/cultivars of *B. juncea* (10), *B. napus* (10) and *B. carinata* (10) for resistant to mustard aphid (*Lipaphiserysimi*). All of B. juncea genotypes were moderately resistant. Among the *B. napus* genotypes, 4 (Milla, DGS-1, Jupiter and Excell) exhibited resistance to mustard aphid. Among the *B. carinata* genotypes, 8 were resistant (PCC-5, PBC-9221, PHC-9221, PC-5, NPC-7, NPC-5, PHC-2 and PCC-2) and 2 were moderately resistant (NPC-27 and PCC-8). *E. sativa* was highly resistant whereas, *Diplotaxissiifolia* and *B. tournefortii* were resistant to mustard aphid.

Bhat*et al.* (2004) conducted an experiment in Jammu and Kashmir, India, during the rabi season to mustard cultivars KS-101, KS-102, KS-103, KS-104, KBS-1, BSH-1, DBS-5, KOS-1 and YSK-151 for resistance to mustard aphid, *Lipapgiserysimi*, revealed that the cultivars were no infested at per-bloom stage. The maximum aphid infestations of 20.96 and 100.66 aphids per plants were recorded at bloom and post-bloom stage, respectively on yellow sarson [*Brassica campestris* var. *sarson*] cv. YSK-151, while the infestation was lowest (8.77 and 46.18 aphids per plant, respectively), on KS-104, BSH-1 was the least resistant cultivar. KS-104 and KS-101 were relatively resistant to aphid infestation, while the remaining cultivars were categorized as moderately susceptible. DBS-5 was the only late flowering cultivars.

Rangre*et al.* (2002) carried out a field trial to screen varieties mustard cultivars, viz. KS-101, KS-102, KS-103, KS-104, KBS-1, BSH-1, DBS-5, KOS-1 and YSK-151 for the presence of the mustard aphid, *L. erysimi*. None of the cultivars studied were infested

with the aphid at per-bloom stage of the crop. During post-bloom stage, maximum aphid population per plant (97.3) was recorded from yellow season cv. YSK-151 followed by BSH-1, BS-1, KS-103, BS-2, KS-102, DBS-5, KOS-1, KS-101. Minimum mean aphid per plant (30.6) was recorded on KS-104.

Takar*et al.* (2003) evaluated twenty genotypes of Inidan mustard for resistance to the mustard aphid, *L. erysimi* in an experiment conducted in Rajasthan, India during the rabi season of 2000-2001. The aphid population was recorded starting from germination and continued at weekly intervals until harvest. The cultivars t-59 (Varuna), BIO-902, PCR-7 (Rajat) and DLM-29 were observed as highly resistant to the pest, with an aphid population of <70.45 aphids per plant. Genotypes Kranti, Pusa Bold, Rohini, VSl-5, BIO-772, DLM-58, Brani, RH-8113, DLM-80 and DLM-68 were moderately resistant (between 70.45 and 116.51 aphids per plant). Genotypes DLM-75, M-21, AG-5, DLRA-343 and *P. Lord* were the least resistant to the pest with more than 116.51 aphids per plant.

Thakur *et al.* (2002) conducted field trials, to screen several *Brassica* cultivars for resistant to *Lipaphiserysimi*cvs. GSL-1510 and ISN-706 had the lowest aphid infestation.

Singh *et al.* (2000) reported that the nine parents and their 36 F_1 hybrids from a diallel cross involved 5 genotypes resistant to mustard aphid and 4 high-yield susceptible genotypes at Hisar under late-sown conditions and evaluated for percent plant infestation by mustard aphid at different stages and for yield components after harvest. Leaf and stem color did not influence mustard aphid incidence at early stages of infestation. Genotype RH-7361, with creamish colored flowers had lower mustard aphid incidence than genotypes with yellow flowers at initial stages of infestation. The presence of hairs on stems and leaves did not influence mustard aphid infestation. The parent RLM-198 registered lower infestation rate. The hybrid B-85 × RLM-198 (R × R) displayed lowest infestation. However, none of the parental lines or their hybrids was observed to be completely free from mustard aphid attack. Percent plant infestation, siliqua per unit length on main stem, siliqualength, 1000-seed weight and seed yield were under the control of both additive and non-additive gene effects. The available genetic variation for resistance in the hybrids is quite narrow under a definite pest pressure that may get

broken down heavy incidence of pest or under no choice conditions. Hence, concrete efforts need to be made to enhance the available level of resistant before their use as donor parents for the development on resistant genotypes. Increasing the available level of resistant by increasing the frequency is recommended. Diallele selective generations are suggested as a means of development resistant genotypes.

Malviya and Lal (2000) showed that screening of 78 *Brassica*germplasms based of the aphid infestation index 15 *Brassica*germplasms were promising against the mustard aphid, *Lipaphiserysimi* (Kalt.) under field conditions during rabi 1997-1998 in Faizbad, India.

Brar*et al.* (1976) investigated sixty six strains of raya and brown sarsonagains Mustard aphid under field as well as artificial condition. They reported 17 strains a resistant 20 strains as susceptible and 6 strains as highly susceptible (to the aphid). Further, they evaluated that the most critical period for screening the cultivars were a s the flowering stage.

Bakhetia and Labana (1978) developed some principle for screening *Brassica* crops for their reaction to aphids, these were injury of plant by aphid population, fecundity longevity, growth and development of the aphids on the aphids on the plants and seed yield of cultivars.

Brar and Sandhu (1987) evaluated some strains of *B. campestris* and *B. juncea*agains*L. erysimi* under field and laboratory condition. They identified some varietirs. Belonging to *B. juncea* group are more resistant to aphid than those belonging to *B. campestris* group, they also reported that RL-18, Rai-23 and Tai-T-6342 are most tolerant to aphid.

Phadke (1992) reared the aphid, *L. erysimi* under field conditions on three varieties of *B. campestris* and one variety of *B. juncea*. He studied them on the basis of net reproductive rate, intrinsic rate of increase and finite rate of increase and found that the *B. campestris* varieties YS-62, PD-24 and T-9 were more favorable for aphid multiplication than other two varieties.

Sahira (1982) observed the effect of different plant part on the development, reproduction and longevity in *L. erysimi* and three existed significant difference in the duration of the nymphal period of *L. erysimi* between different parts of the plant. The reproductive rate was significantly higher on the inflorescence than on the pods.

Singh *et al.* (1982) investigated the reaction of mustard varieties Camp-3, Appressed, Rey-75-1and Pusakalyani, Brown sarson K-1, Varuna and Rey-75-2 to infestation by *L. erysimi* in the field. They graded these varieties on the basis of the number of aphids found on them and reported that the variety Brown sarson K-1 was the most susceptible to aphid.

Husain and Begum (1984) evaluated some varieties/lines of mustard for their susceptibility to the aphid, *L. erysimi* under field and laboratory condition. They found that the varieties of *Juncea* group were comparatively more resistant to aphid than *B. campestris*. They identified YS-67 and Tori-7 are highly susceptible to aphid and BINA-M-46, BINA-M-59, M-248 and R-5 are resistant or tolerant to the aphid.

Prasad (1983) screening 159 indigenous and 17 exotic germplasms of *B. juncea* for resistance to *L. erysimi* of these, 71 germplasms were less susceptible than the average.

Kabir (1987) evaluated 12 mustard germplasms against mustard aphid, *L. erysimi* (Kalt.) for their susceptibility. He graded the mustard germplasms based on aphid infestation percentage and grouped into following: BINA-M-46, BINA-M-59, M-126-17, M-258 and Sambal were tolerant; M-151, M-127 and M-110-7 were susceptible; M-4 was highly susceptible; Sampad, Kallyania and YS-67 were moderately susceptible to mustard aphid.

Prasad and Phadka (1987) investigated 50 *Brassica* genotypes for susceptible to aphid in the field. Among the genotypes *B. nigra* (Tall), RLM-29, RLM-29/25, RML-84, RML-171 and P-11/71 were found least susceptible to *L. erysimi*.

Rohila*et al.* (1987) conducted that an experiment with six *Brassica* genotypes for their resistance to *L. erysimi* based on yield loss as the criterion of resistance they reported the following decreasing order of resistance. *Eruce sativa* T-27 (16.44 % yield less). *B. juncea* 'Parkesh' (23.64 %), RH-30 (27.31 %), *B. campestris* brown sarson 'BSH-1' (32.73 %), yellow sarson 'YS-PB-24' (34.18 %) and *B. napus* 'HNS-3' (61.32 %).

Malik (1988) compared the genotypes belonging to species of *B. juncea, B. napus, B. nigra* and 3 strains *B. campestris*for their susceptibility to aphid, *L. erysimi*. He did not find any variety resistant to aphids, but reported some varieties to be susceptible to aphids.

Ram *et al.* (1989) evaluated fifty seven varieties of fodder mustard (*Brassica* spp.) for resistance to *L. erysimi* and reported that the variety IM-76 was highly resistant to the aphid.

Roy and Baral (2001) conducted an experiment at pulses and oilseeds research station, Berhampore, Murishidabad, West Bangal, India during the rabi season of 1992-1993, 1993-1994 and 1994-1995 to study the effect of the mustard aphid, *L. erysimi* on mustard yield and its attributes. The three cultivars i.e.; RW var. sarson were selected for the experiments, which uses nine treatments of different aphid pressure regimes. As the aphid exposure period increased there was a gradual decrease in yield, number of siliqua per plant and 1000-seed weight, with the highest yield being obtained from the treatments giving complete plant protection. The correlation studies revealed significant negative relationships among aphid population and mustard yield and its attributes.

Srivastava*et al.* (1996) conducted an experiments and reported that yellow sarson cultivar (YST-841) suffered the maximum yirld less (46.12 %) due to infestation by *Myzuspersicae* and *L. erysimi*, follow ed by brown sarson (BSH-1, 43.58 %), *B. juncea* (Vatruna) and *B. napus* (HPN-1) showed lower susceptibility with yield losses from 30.90 % to 36.01 % *B. carinta* (HPC) was the least susceptibility with 22.94 % yield loss.

2.4 Yield loss due to mustard aphid infestation

Rohila*et al.* (1987) conducted a four year investigation with six *Brassica* for their resistance to *Lipasphiserysimi* (Kalt.). The investigators used the yield loss as the criteria of resistance and reported the following decreasing order of resistance *Erucs sativa* t-27 (16.44 % yirld loss), *B. juncea*parkesh (23.64 %), RH-30 (27.31 %), *B. campestris* brown sarson BSH-1 (32.73 %), yellow sarson YS-PB-24 (34.18 %) and *B. napus* HNS-3 (61.32 %).

Sekhon and Ahman (1992) expressed that *L. erysimi* (Kalt.) is the most devastating insect pest in India where it can cause losses of up to 50 % in seed yield.

Begum (1994) conducted a research experiment with three varieties of mustard in Joydebpur in the year 1993-1994 to assess the loss sue to aphid infestation. It was found that second highest losses occur in the flowering and poding stages and the lowest losses occur in the pod formation and ripening stage.

Begum (1995) conducted an experiment at ARS rajbari, Dinajpur during radi season of 1994-1995 to find out the population activities of mustard aphid. She observed that aphid population increases gradually as sowing delayed. The highest aphid population was recorded 2879.12 per plant and the lowest aphid population 259.35 per plant. It was evident that the mustard yield decreased as the aphid population increased and the percent of pod infestation had positive correlation to aphid population.

Bhadauria*et al.* (1995) evaluated thirty Indian mustard cultivars under field conditions against *L. erysimi* on the basis of mean aphid population, multiplication index and the susceptibility index. They suggested that low susceptibility index and higher grain yield (2060 kg ha^{-1}) in cv. RW-5453-B-2 seemed to be suitable for general cultivation.

Anonymous (1995) conducted a field experiment with eleven varieties/ mutant of mustard to measure the loss of yield due to aphid infestation. The mutant/ varieties included in the test were Agrain, Safal, BINA-2, NAP-3, SS-75, Tori-7, Tori-68, Sangam and BS-5. The investigators reported that the mutant/ varieties were significantly different among themselves with respect to seed yield. The highest yield was obtained in NAP-3 and the lowest in BS-5.

Srivastava*et al.* (1996) performed field trials in Himachal Pradesh, India during 1991-1994 to assess the yield loss of mustard due to infestation of *Myzuspersicae* and *L. erysimi*. They observed that the yellow sarson cultivar (YST-8410) showed the maximum yield loss (46.12 %) and brown sarson BSH-1 showed (43.58 %), *B. juncea* (Varuna) and *B. napus* (HPS-1) showed lower susceptibility with yield loss ranging from 30.90 % to 36.01 %. *B. carinata* (HPC-1) was the least susceptible cultivar with 22.84 % yield loss.

Agarwal*et al.* (1996a) carried out a field experiment under the agro climate conditions of Haryana, India to find out the effect of infestation by *L. erysimi* on yield contributing traits of 20 rape/mustard genotypes. They investigated on the basis of lesser influence of aphid infestation on yield contributing traits such as plant height, primary branches, main shoot length, siliqua on main shoot, siliqualangth, number of seed per siliqua and 1000-seed weight the four genotypes HC-2 (*B. carinata*), T-6342 (*B. juncea*). TMN-52 (*Eruca sativa*) and *B. tourneforyii* appeared promising.

2.5 Influence of morphological characters of mustard plant on aphid infestation

Several investigators studies the morphological characters of mustard plant in relation to aphid infestation. A brief account of experimental results, conducted results, conducted by different researchers on the above mentioned topic is presented below for comparison.

Srivastava*et al.* (1972) carried an experiment to observe susceptibility of different varieties of *B. campestris* and *B. juncea* to aphids. They concluded that the varieties having taller plants were less susceptible to aphids than shorter ones.

Begum (1988) made the correlation between plant height and percentage of infestation by aphid and found that the percentage of aphid infestation was inversely proportional to the plant height of the cultivars under test.

Kumar *et al.* (1994) evaluated nine resistant and susceptible *B. juncea* genotypes under field condition during 1989-1990 in India. They reported that morphological characters viz. glossiness of leaf and stem influenced the incidence of mustard aphid in early stages of crop growth.

Agarwal*et al.* (1996b) implemented a field experiment in India to evaluate the influence of crop morphological parameters of 20 *Brassica* genotypes against of the aphids (*L. erysimi*). They concluded that flowering behavior were negatively correlated with peak population of *Lipaphiserysimi* (Kalt.).

CHAPTER III

MATERIALS AND METHODS

The study was conducted on suitable sowing time and varietal screening of mustard against aphid, *Lipaphiserysimi* (Kalt.). The research work was conducted during the period from November 2013 to February 2014 (Rabi season) at the Research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh.

3.1 Experimental period

The experiment was conducted during rabi (winter) season from first week of November, 2013 to February, 2014.

3.2 Location

The piece of research work was conducted in the experimental plot of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The experimental site belongs to the agro-ecological zone of "ModhupurTract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain.

3.3 Soil characteristics

Top soil of the experimental field was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45% (Haider*et al.*, 1991). The experimental area was flat having available irrigation and drainage system and above flood levels. The selected plot was medium high land. The details were presented in Appendix I.

3.4 Climate of the experimental site

Experimental site was located in the sub-tropical monsoon climatic zone. The experiment was carried out during the months from November, 2013 to February, 2014 (rabi season). Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for mustard growing in Bangladesh. The weather data during the study period at the experimental site are shown in Appendix II.

3.5 Details of the experiment

The details of the experiment considering experimental materials, experimental design, land preparation, fertilizer application, sowing of seeds, intercultural operations have been discussed in the following sub-head:

3.5.1 Planting material

The eight varieties of mustard were collected from the different sources used in the study. Tori-7 was collected from Sher-e-Bangla Agricultural University (SAU) and other seven BARI verities were collected from Oilseed Division of Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.

3.5.2 Experimental design and layout

The experiment was laid out in Two-factorial Randomized Complete Block Design (RCBD) with three replications thus comprised 72 plots. The layout of the experiment was prepared for distributing the combination of sowing time and different varieties of mustard. The size of each unit sub plot assigned for each variety was 2.5 m × 1.5 m. The spacing between blocks and plots were 0.75 m and 0.5 m, respectively. The experiment was laid out in factorial Randomized Complete Block Design (RCBD), where sowing time was considered as first factor with three levels and mustard variety was considered as second factor with eight levels (varieties). The factor wise different levels or treatments of experiment were as follows:

Factors	Levels	Treatments
Factor A (Sowing times)	S_1	9 November, 2013
	S_2	16 November,2013
	S_3	23 November,2013
Factor B (Mustard varieties)	V_1	Tori-7
	V_2	BARI Sharisha-6
	V_3	BARI Sharisha-9
	V_4	BARI Sharisha-11
	V_5	BARI Sharisha-13
	V_6	BARI Sharisha-14
	V_7	BARI Sharisha-15
	V_8	BARI Sharisha-16

3.5.3 Land preparation

The soil was well prepared, good tilth was ensured for commercial crop production. The target land was divided into 72 equal plots (2.5 m × 1.5 m) with plot to plot distance 0.5 m and block to block 0.75 m. The land of the experimental field was ploughed with a power tiller. Then the land preparation was started 10 days before sowing of mustard seeds. Later on the land was prepared with three ploughing followed by laddering and proper leveling to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering and the stubbles and uprooted weeds removed and then the land was ready.

3.5.4Fertilizer application

The crop was fertilized as per recommendation of BARC (1999).The experimental plot was fertilized with following dose of urea, triple super phosphate (TSP), gypsum, zinc sulphate and boric acid.

Cow dung was applied 10 days before final land preparation. Total amount of triple superphosphate, gypsum, zinc sulphate, boric acid and half of urea was applied at basal doses during final land preparation. The remaining 50% urea was topdressed at 40 days after sowing (DAS).

Fertilizers	Dose (kg ha^{-1})	Dose (g $plot^{-1}$)
Cow dung	10,500	1000
Urea	150	43.25
TSP	75	22.00
MoP	150	45.00
Gypsum	75	22.00
Zinc sulphate	5	1.20
Boric Acid	10	2.50

3.5.5Sowing of seed

Each of the eight selected mustard varieties was treated as an individual treatment. Before sowing the seeds germination test was done in the laboratory of the Department of Entomology and the 90% germination was found for all varieties. Seeds @ 8 kg ha^{-1} were then directly sown in the field considering three sowing dates at seven (7) days interval

such as 9 November (S_1), 16 November (S_2) and 23 November (S_3), 2013. After germination, the seedlings in the field were sprayed with water by a watering cane. Soil of the experimental units was watered 3-4 days in a week up to considerable growth of the plants.

3.5.6 Intercultural operations

Thinning was done at 15 DAS. Weeding was done to keep the plant free from weeds. The newly emerged weeds were uprooted carefully after complete emergence of sprouts and afterwards when necessary.

3.6 Data collection

For data collection ten (10) plants per plot were randomly selected and tagged. Data collection was started in the field at 42 days after sowing (DAS) for all of three sowing times. All the data were collected once a week. The data were collected as on different parameters such as number of aphid per plant, number of aphid infested plants per plot, number of aphid infested inflorescence at 42, 49 and 56 DAS, number of total and infested siliqua per plant at 65 DAS, plant height, pod length, number of seeds per pod, and total yield per plot at maturity.

3.6.1 Procedure for counting of aphid population

The number aphid on 10 randomly selected plants from each plot was counted at 42, 49 and 56 DAS. The top 10 cm apical twigs of three randomly selected inflorescences of the selected plants were cut with sharp knife and brought to the laboratory in clear polythene bags separately for counting the number of aphid per plant. The aphids were removed from the infested plant parts with the help of a soft camel hair brush and placed on a piece of white paper. Then the number of aphids was counted with the help of a magnifying glass and tally counter. The infested twigs and inflorescences were checked carefully, so that, single aphid could not escape at the time of counting.

3.6.2 Collection of yield contributing data

The crops were harvested at full maturity stage from 15 February to 20 February, 2014. For the purpose of the study of yield contributing character viz. data on number of total

and infested siliqua per plant, plant height, pod length per plant and yield of five healthy plants and five infested plants were recorded.

3.7 Data calculation

A brief outline of the data calculation on the collected data is given below:

3.7.1 Percent of aphid infested plant by number

Number of aphid infested plant was counted from total plants per plot and percent plant infestation by aphid was calculated by using the following formula:

$$\% \text{ aphid infested plant} = \frac{\text{No.of aphid infested plant}}{\text{Total no.of plant per plot}} \times 100$$

3.7.2 Percent of aphid infested inflorescence

The total number of aphid infested and uninfested inflorescence at flowering and pod forming stage were counted from randomly selected 10 plants per plot and percent plant infestation by aphid was calculated by using the following formula:

$$\% \text{ aphid infested inflorescence} = \frac{\text{No.of aphid infested inflorescence}}{\text{Total no.of inflorescence per plot}} \times 100$$

3.8 Data analysis

The data obtained for different parameters were statistically analyzed following the analysis of variance techniques by using MSTAT-C computer package. The significant differences among the treatment means were compared by Least Significant Difference (LSD) test and Duncun's Multiple Range Test (DMRT) at 1% and 5% levels of probability where appropriate (Gomez and Gomez, 1984).

Plate 1. Experimental plot at Sher-e-Bangla agricultural university

= 

Plate2. Data collection in experimental field

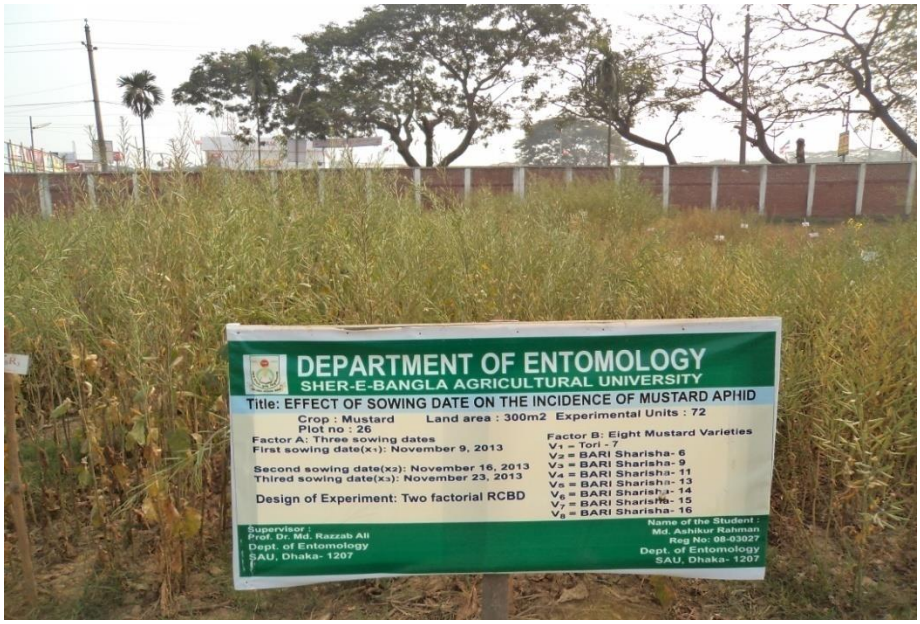

Plate 3. Experimental field at maturity

Plate 4. Severely aphid infested mustard plant

Plate 5. Severely aphid infested siliqua

Plate 6. Less aphid infested siliqua

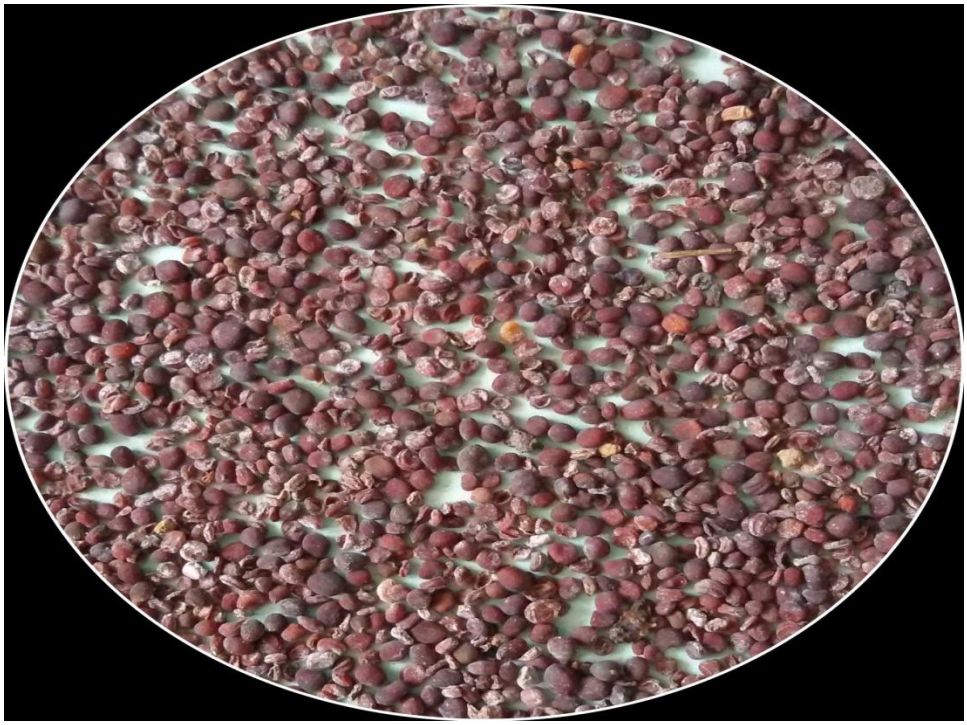

Plate 7. Deformed mustard seeds collected from severely aphid infested field

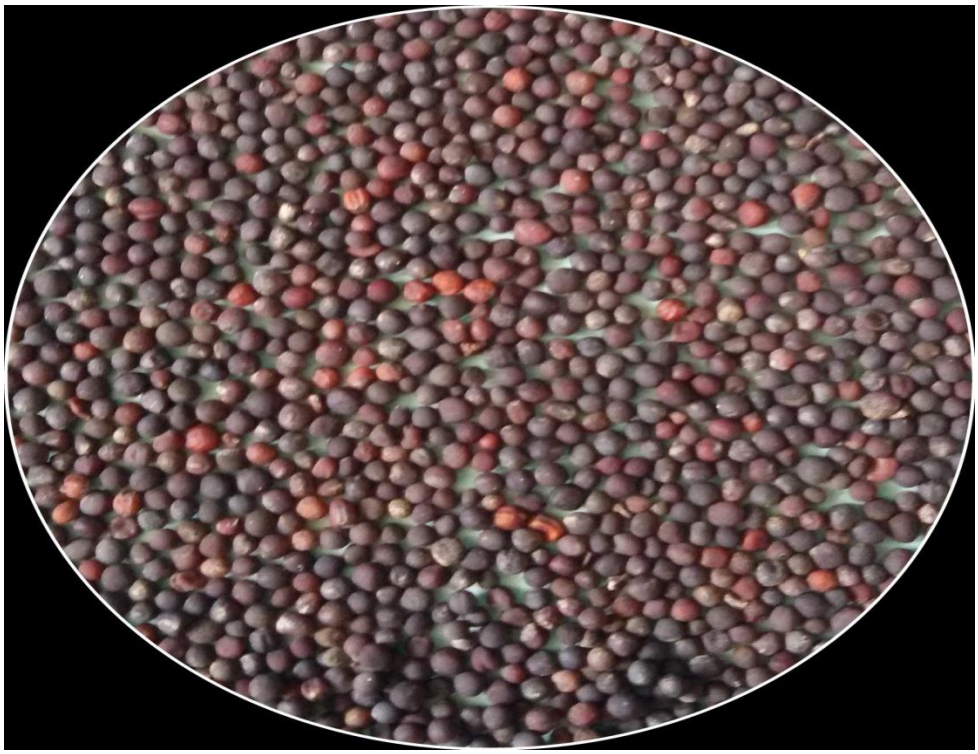

Plate 8.Healthy mustard seed collected from least aphid infestedfield

CHAPTER IV

RESULTS AND DISCUSSIONS

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during rabi (winter) season of 2013-2014 to evaluate eight mustard varieties namely- Tori-7, BARI Sharisha-6, BARI Sharisha-9, BARI Sharisha-11, BARI Sharisha-13, BARI Sharisha-14, BARI Sharisha-15, BARI Sharisha-16 cultivated in three different sowing times considering 7 days interval namely 9 November (S_1), 16 November (S_2) and 23 November (S_3) to find out the tolerant variety(ies) and effective time of sowing against mustard aphid. The findings of the study have been presented and discussed under the following sub-headings:

4.1. Effect of sowing times on plant infestation by aphids

Significant variations were observed among three sowing time of mustard on plant infestation by aphids at different days after sowing (DAS) of mustard seeds (Table 1). In case of 1st observation (42 DAS), the highest plant infestation (49.59%) by aphid was observed in late sowing time S_3(23 November), which was statistically different from other two sowing times. This was followed by plant infestation that was recorded in S_2 (16 November). On the other hand, the lowest plant infestation (30.41%) was recorded in early sowing S_1 (9 November). More or less similar trends of results were observed at both 2nd observation (49 DAS) and 3rd observation (56 DAS). Where, in case of 49 DAS, the highest plant infestation (89.59%) was observed in S_3, which was statistically different from other two sowing times. This was followed by plant infestation that was recorded in S_2. On the other hand, the lowest plant infestation was recorded in S_1. In case of 56 DAS, the highest plant infestation (96.26%) was observed in S_3, which was statistically different from other two sowing times. This was followed by plant infestation that was recorded in S_2. However,the lowest plant infestation (61.16%) by aphid was recorded in S_1.

Considering the mean infestation, the highest plant infestation (78.48%) was observed in late sowing (S_3), which was statistically different from other two sowing times. This was

followed by 57.73% in plant infestation by aphids observed in S_2. Conversely , the lowest plant infestation (49.41%) was recorded in S_1.Nasir*et al.* (1998) also observed that late sowing positively correlate with plant infestation by aphid. Due to late sowing aphid population increased as the result of higher relative humidity was observed by Biswas and Das (2000).

Table 1. Effect of sowing time on plant infestation of mustard by aphid at different days after sowing (DAS)

Treatments	Plant infestation (%) at			
	42 DAS*	49 DAS*	56 DAS*	Mean
S_1 (9 November)	30.41 c	56.66 b	61.16 c	49.41 c
S_2 (16 November)	39.85 b	58.76 b	74.59 b	57.73 b
S_3 (23 November)	49.59 a	89.59 a	96.26 a	78.48 a
$LSD_{(0.01)}$	5.17	5.09	3.07	1.45
CV (%)	12.87	7.40	3.94	5.48

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD test at 0.01 level of probability.

From these above findings it is stated that the early sowing (S_1) illuminated the minimum aphid infestation on mustard plant (49.41%) and the maximum plant infestation was found at late sowing of mustard seed.Saha and Kanchan (1999),alsoobserved maximum aphid population in delayed sowing.

4.2. Effect of mustard varieties on plant infestation by aphids

Significant variations were observed among eight mustard varieties on plant infestation by aphids at different days after sowing (Table 2). In case of 42 DAS, the highest plant infestation (64.33%) by aphids was recorded in mustard variety V_1 (Tori-7), which was statistically different from all other varieties which was followed by plant in V_3 (54.43%), V_6 (38.90%) and V_8 (35.58%). Conversely, the lowest plant infestation (25.56%) was recorded in V_5 (BARI Sharisha-13), which was followed by V_4 (33.33%), V_7 (33.37%) and V_2 (34.10%). More or less similar trends of results were observed at both 49 DAS and 56 DAS. In case of 49 DAS, the highest infestation (83.37%) by aphids was recorded in V_1 (Tori-7), which was statistically different from all other mustard varieties. This was followed by (77.77%) plant infestation in V_3 followed by V_6 (74.47%) and V_4 (65.53%). Contrastingly, the lowest plant infestation (55.57%) was recorded in V_5 (BARI Sharisha-13), which was followed by V_8 (62.20%), V_7 (63.33%) and V_2 (64.47%). Similes in case of

56 DAS, the highest infestation (94.47%) by aphids was recorded in V_1 (Tori-7), which was statistically different from all other mustard varieties. This was followed by V_3 (94.43%), V_4 (84.47%) and V_8 (75.53%). On the other hand, the lowest plant infestation (58.23%) was recorded in V_5 (BARI Sharisha-13), which was followed by V_2 (66.67%), V_7 (71.57%) and V_6 (73.33%).

Considering the mean infestation, the highest plant infestation (80.71%) was observed in V_1 (Tori-7),which was statistically different from other seven mustard varieties. This was followed by V_3 (75.55%), V_6 (62.23%) and V_4 (61.11%). On the other hand, the lowest infestation (46.45%) was V_5 (BARI Sharisha-13).

Table 2. Effect of variety on plant infestation of mustard by aphid at different days after sowing (DAS)

Treatments	Plant infestation (%) at			
	42 DAS*	49 DAS*	56 DAS*	Mean
V_1 (Tori-7)	64.33 a	83.37 a	94.47 a	80.71 a
V_2 (BARI Sharisha-6)	34.10 c	64.47 c	66.67 d	55.07 d
V_3 (BARI Sharisha-9)	54.43 b	77.77 ab	94.43 a	75.55 b
V_4 (BARI Sharisha-11)	33.33 cd	65.53 c	84.47 b	61.11 c
V_5 (BARI Sharisha-13)	25.56 d	55.57 d	58.23 e	46.45 e
V_6 (BARI Sharisha-14)	38.90 c	74.47 b	73.33 c	62.23 c
V_7 (BARI Sharisha-15)	33.37 cd	63.33 cd	71.57 cd	56.09 d
V_8 (BARI Sharisha-16)	35.58 c	62.20 cd	75.53 c	57.77 d
$LSD_{(0.01)}$	8.45	8.04	5.01	2.85
CV (%)	12.87	7.40	3.94	5.49

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

From this above findings it was revealed that the mustard variety of BARI sharisha-13 manifested the lowest (46.45%) plant infestation by aphids followed by BARI sharisha-11, whereas Tori-7 manifested the highest aphid infestation (80.71%).

Considering the rate of aphid infestation, the order of plant infestation among mustard varieties is $V_1>V_3>V_6>V_4>V_8>V_7>V_2>V_5$. Similar works were also done by several workers. This results were in agreement with those of Husain and Begum (1984), Husain and Shahjahan (1997), Kabir (1987), Begum (1988), who also regarded Tori-7 as highly susceptible to mustard aphid.

4.3. Interaction effect of sowing time and varieties on plant infestation by aphid

Interaction effect of sowing time and varietyshowed significant variations in plant infestation by aphids at different days after sowing of mustard seeds (Table 3). In case of

42 DAS, the highest plant infestation (80.00%) by aphid was recorded in V_1 (Tori-7) sown in S_3 (late sowing time), which was followed by 56.30% plant infestation in V_6 sown in S_2 followed by 53.00% plant infestation in V_1 sown in S_1. On the other hand, the lowest plant infestation (10.00%) by aphids was recorded in mustard variety V_5 sown in S_1, this was followed by 13.30% plant infestation in V_4 sown in S_1 followed by 16.70% plant infestation in V_5 sown in S_3.

Table 3. Interaction effect of sowing time and variety on plant infestation of mustard by aphid at different days after sowing

Sowing time	Variety	Plant infestation (%) at			
		42 DAS*	49 DAS*	56 DAS*	Mean
S_1	V_1	53.00 bc	66.70 f	83.30 c	67.67 j
	V_2	20.00 hi	50.00 hi	66.70 d	45.57 s
	V_3	36.70 ef	43.30 ij	48.00 g	42.67 t
	V_4	13.30 ij	40.00 jk	60.00 e	37.77 v
	V_5	10.00 j	33.30 k	40.00 h	27.76 w
	V_6	36.70 ef	50.00 hi	83.30 c	56.67 n
	V_7	40.00 d-f	80.00 de	96.70 ab	72.76 h
	V_8	56.70 b	90.00 bc	96.70 ab	81.13 d
S_2	V_1	35.70 ef	56.70 gh	66.00d	52.80 q
	V_2	33.33 fg	60.00 fg	68.00 d	53.78 p
	V_3	33.33 fg	36.70 jk	50.00 fg	40.01 u
	V_4	43.30 de	53.30 gh	86.70 c	61.10 l
	V_5	33.30 fg	76.70 e	82.00 c	64.00 k
	V_6	56.30 b	96.70 ab	100.0 a	84.33 c
	V_7	46.70 cd	93.30 a-c	100.0 a	80.00 e
	V_8	46.70 cd	86.70 cd	96.70 ab	76.70 f
S_3	V_1	80.00 a	100.0 a	100.0 a	93.33 a
	V_2	26.70 gh	56.70 gh	83.30 c	55.57 o
	V_3	56.70 b	86.70 cd	100.0 a	81.13 d
	V_4	33.30 fg	53.30 gh	86.70 c	57.57 m
	V_5	16.70 ij	60.00 fg	70.00 d	48.90 r
	V_6	53.30 bc	96.70 ab	100.0 a	83.33 b
	V_7	33.33 fg	93.30 a-c	96.70 ab	74.44 g
	V_8	36.70 ef	80.00 de	93.30 b	70.00 i
$LSD_{(0.01)}$		8.45	8.04	5.01	0.45
CV (%)		12.87	7.40	3.94	1.79

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

[S_1=Seeds sown in 9 November, 2013; S_2= Seeds sown in 16 November 2013 and S_3=Seeds sown in 23 November, 2013. V_1=Tori-7, V_2=BARI sharisha-6, V_3=BARI sharisha-9, V_4=BARI sharisha-11, V_5=BARI sharisha-13, V_6=BARI sharisha-14, V_7 =BARI sharisha-15 and V_8=BARI sharisha-16.]

More or less similar trends of results were observed in 49 DAS and 56 DAS. But the rate of plant infestation by aphids was increased with increase of plant ages.From this above findings it was revealed that the V_5 (BARI sharisha-13) manifested the lowest plant infestation (27.76%) by aphids when it was sown early in the season (S_1) and conversely, the V_1 (Tori-7) manifested the highest plant infestation (93.33%) by aphids when it was sown in late (S_3).

4.4. Effect of sowing time on inflorescence infestation by aphids

Significant variations were observed among three sowing time of mustard on inflorescence infestation by aphids at different days after sowing (DAS) of mustard seeds (Table 4). In case of 42 DAS, the highest inflorescence infestation (42.75%) by aphids was observed in late sowing S_3(23 November), which was statistically different from other two sowing times. This was followed by inflorescence infestation that was recorded in S_2 (16 November). On the other hand, the lowest inflorescence infestation (20.47%) was recorded in early sowing time S_1 (9 November). More or less similar trends of results were observed at both 49 DAS and 56 DAS. Where, in case of 49 DAS, the highest inflorescence infestation (95.60%) was observed in S_3, which was statistically different from other two sowing times. This was followed by inflorescence infestation that was recorded in S_2. On the other hand, the lowest inflorescence infestation (20.85%) was recorded in S_1. Similarly, in case of 56 DAS, the highest inflorescence infestation (98.09%) was observed in S_3, which was statistically different from other two sowing times. This was followed by inflorescence infestation that was recorded at S_2. On the contrary, the lowest inflorescence infestation (91.71%) by aphids was recorded at S_1.

Considering the mean infestation, the highest inflorescence infestation (78.81%) was observed in late sowing (S_3), which was statistically different from other two sowing times. This was followed by (53.32%) inflorescence infestation by aphids observed in S_2. On the other hand, the lowest inflorescence infestation (44.34%) was recorded in S_1.

Table 4. Effect of sowing time on inflorescence infestation of mustard by aphid at different days after sowing (DAS)

Treatments	Inflorescence infestation (%) at			
	42 DAS*	49 DAS*	56 DAS*	Mean
S_1 (9 November)	20.47 c	20.85 c	91.71 b	44.34 c
S_2 (16 November)	21.61 b	45.54 b	92.81 b	53.32 b
S_3 (23 November)	42.75 a	95.60 a	98.09 a	78.81 a
$LSD_{(0.01)}$	0.25	2.62	3.37	4.57
CV (%)	1.86	4.83	3.56	2.48

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD test at 0.01 level of probability.

From these above findings it was revealed that the early sowing (S_1) manifested the lowest aphid infestation on mustard inflorescence (44.34%) and the highest inflorescence infestation was recorded at late sowing of mustard seed. Singh, *et al*., (1965),also found that mustard aphids prefer flowers to leaves.

4.5. Effect of mustard varieties on the infestation of inflorescence by aphids

Significant variations were observed among eight mustard varieties on the infestation of inflorescence by aphids at different days after sowing (Table 5). In case of 42 DAS, the highest inflorescence infestation (45.57%) by aphids was recorded in mustard variety V_1 (Tori-7), which was statistically different from all other varieties. This was followed by inflorescence in V_3 (37.53%), V_2 (28.30%) and V_4 (28.26%). On the other hand, the lowest inflorescence infestation (19.34%) was recorded in V_5 (BARI sharisha-13), which was followed by V_8 (20.11%), V_7 (20.93%) and V_6 (26.17%). More or less similar trends of results were observed at both 49 DAS and 56 DAS. In case of 49 DAS, the highest infestation (78.67%) by aphids was recorded in V_1 (Tori-7), which was statistically different from all other mustard varieties. This was followed by (62.57%) inflorescence infestation in V_3 followed by V_6 (59.63%) and V_4 (51.17%). On the other hand, the lowest inflorescence infestation (37.70%) was recorded in V_5 (BARI Sharisha-13), which was followed by V_8 (45.63%), V_2 (46.90%) and V_7 (49.70%). Similarly, in case of 56 DAS, the highest inflorescence infestation (99.87%) by aphids was recorded in V_1 (Tori-7), which was statistically different from all other mustard varieties. This was followed by V_6 (99.17%), V_7 (98.03%) and V_2 (97.60%). On the other hand, the lowest inflorescence infestation (74.37%) was recorded in V_5 (BARI Sharisha-13), which was followed by V_8 (92.83%), V_3 (95.80%) and V_4 (95.97%).

Considering the mean infestation, the highest inflorescence infestation (74.70%) was observed in V_1 (Tori-7), which was statistically different from other seven mustard

varieties. On the other hand, the lowest infestation (43.80%) was recorded in variety V_5 (BARI sharisha-13).

Table 5.Effect of variety on inflorescence infestation of mustard by aphid at different days after sowing

Treatments	Inflorescence infestation (%) at			
	42 DAS*	49 DAS*	56 DAS*	Mean
V_1 (Tori-7)	45.57 a	78.67 a	99.87 a	74.70 a
V_2 (BARI Sharisha-6)	28.30 c	46.90 cd	97.60 ab	57.60 d
V_3 (BARI Sharisha-9)	37.53 b	62.57 b	95.80 ab	65.30 b
V_4 (BARI Sharisha-11)	28.26 c	51.17 c	95.97 ab	58.47 d
V_5 (BARI Sharisha-13)	19.34 g	37.70 e	74.37 c	43.80 g
V_6 (BARI Sharisha-14)	26.17 d	59.63 b	99.17 a	61.65 c
V_7 (BARI Sharisha-15)	20.93 e	49.70 cd	98.03 b	56.22 e
V_8 (BARI Sharisha-16)	20.11 f	45.63 d	92.83 b	52.86 f
$LSD_{(0.01)}$	0.39	4.29	5.51	1.47
CV (%)	1.86	4.83	3.56	2.45

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

From this above observation it was found that the mustard varieties V_5 (BARI Sharisha-13) manifested the lowest (74.70%) inflorescence infestation by aphids followed by V_4 (BARI sharisha-11), while V_1(Tori-7) manifested highest aphid infestation (43.80%).

Considering the infestation of inflorescence by Aphid the sequence of varieties from highest to lowest infestation is $V_1>V_3>V_6>V_4>V_8>V_7>V_2>V_5$ which might be due to the inherited or genetic quality or tolerance to Aphid infestation. This result was in harmony with Islam (1991), who also revealed that the highest incidence of aphid infested inflorescence recorded in Tori-7.

Considering the rate of aphid infestation, the order of inflorescence infestation among highest mustard varieties is $V_1>V_3>V_6>V_4>V_8>V_7>V_2>V_5$. About similar works also done by several workers. This result was in harmony with Islam (1991), who also regarded that the highest incidence of aphid infested inflorescence recorded in Tori-7.

4.6. Interaction effect of sowing time and mustard varieties on inflorescence infestation by aphid

Interaction effect of sowing time and varietyshowed significant variations in inflorescence infestation by aphids at different days after sowing of mustard seeds (Table 6). In case of 42 DAS, the highest inflorescence infestation (61.50%) by aphid was

recorded in V_1 (Tori-7) sown in S_3 (late sowing time), which was followed by 59.80% inflorescence infestation in V_6 sown in S_2 followed by 57.10% inflorescence infestation in V_6 sown in S_3.

Table 6. Interaction effect of sowing time and variety on inflorescence infestation of mustard by aphid at different days after sowing

Sowing time	Variety	Inflorescence infestation (%) at			
		42 DAS*	49 DAS*	56 DAS*	Maen
S_1	V_1	33.50 j	62.57 c	91.50 cd	62.53 f
	V_2	14.60 o	51.17 d	100.0 a	55.26 l
	V_3	12.20 r	49.70 de	96.80 a-c	52.90 n
	V_4	15.60 n	29.60 hi	92.80 b-d	46.00 r
	V_5	9.10 t	21.00 kl	64.50 g	31.53 t
	V_6	12.20 r	23.30 jk	88.40 de	41.30 u
	V_7	26.70 k	46.90 de	100.0 a	56.87 j
	V_8	41.53 f	59.63 c	100.0 a	67.05 d
S_2	V_1	12.20 r	46.90 de	100.0 a	53.03 m
	V_2	11.33 s	37.70 f	73.90 f	40.98 s
	V_3	12.60 q	45.63 e	90.10 de	49.44 o
	V_4	24.70 l	28.00 i	87.90 de	46.87 q
	V_5	23.17 m	49.60 de	98.70 a	57.16 i
	V_6	59.80 b	62.57 c	100.0 a	74.12 c
	V_7	45.47 d	51.17 d	100.0 a	65.55 e
	V_8	38.30 g	49.70 de	100.0 a	62.67 f
S_3	V_1	61.50 a	100.0 a	100.0 a	87.17 a
	V_2	13.80 p	59.63 c	98.80 a	57.41 i
	V_3	43.40 e	45.63 e	95.90 a-c	61.64 g
	V_4	24.70 l	28.00 i	87.90 de	46.87 q
	V_5	12.30 qr	33.20 gh	97.30 ab	47.60 p
	V_6	57.10 c	78.67 b	100.0 a	78.59 b
	V_7	37.60 h	45.70 e	84.70 e	56.00 k
	V_8	35.53 i	45.63 e	100.0 a	60.39 h
$LSD_{(0.01)}$		0.39	4.29	5.51	0.78
CV (%)		1.86	4.83	3.56	1.03

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

[S_1=Seeds sown in 9 November, 2013; S_2= Seeds sown in 16 November 2013 and S_3=Seeds sown in 23 November, 2013. V_1=Tori-7, V_2=BARI sharisha-6, V_3=BARI sharisha-9, V_4=BARI sharisha-11, V_5=BARI sharisha-13, V_6=BARI sharisha-14, V_7 =BARI sharisha-15 and V_8=BARI sharisha-16.]

On the other hand, the lowest inflorescence infestation (9.10%) by aphids was in mustard variety V_5 sown in S_1, this was followed by 11.33% inflorescence infestation in V_2 sown in S_2.

More or less similar trends of results were observed in 49 DAS and 56 DAS. But the rate of inflorescence infestation by aphids was increased with increase of plant ages.

From the above findings it was revealed that the V_5 (BARI sharisha-13) manifested the lowest inflorescence infestation (31.53%) by aphids when it was sown early (S_1) and conversely, the V_1 (Tori-7) manifested the highest inflorescence infestation (87.17%) by aphids when it was sown in late (S_3).

4.7. Effect of sowing time on aphid population

Significant variations were observed among three sowing time of mustard on number of aphid population at different days after sowing (DAS) of mustard seeds (Table 4). In case of 42 DAS, the highest aphid population (186.0) was observed in late sowing S_3(23 November), which was statistically different from other two sowing times. This was followed by aphid population that was recorded in S_2 (16 November). On the other hand, the lowest aphid population (82.05) was recorded in early sowing time S_1 (9 November). More or less similar trends of results were observed at both 49 DAS and 56 DAS. Where, in case of 49 DAS, the highest aphid population (191.2) was observed in S_3, which was statistically different from other two sowing times. This was followed by aphid population that was recorded in S_2. On the other hand, the lowest aphid population (115.9) was recorded in S_1. Similes**,** in case of 56 DAS, the highest aphid population (222.2) was observed in S_3, which was statistically different from other two sowing times. This was followed by aphid population that was recorded in S_2. On the other hand, the lowest aphid population (119.2) was recorded in S_1.

Table 7. Effect of sowing time on the incidence of aphid at different days after sowing

Treatments	Aphid population (No./top 10 cm inflorescence) at			
	42 DAS*	49 DAS*	56 DAS*	Mean
S_1 (9 November)	82.05 c	115.9 c	119.2 c	105.71 c
S_2 (16 November)	109.1 b	155.7 b	177.3 b	147.37 b
S_3 (23 November)	186.0 a	191.2 a	222.2 a	199.80 a
$LSD_{(0.01)}$	5.74	7.69	4.77	6.59
CV (%)	4.54	5.06	3.04	3.67

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD test at 0.01 level of probability.

Considering the mean infestation, the highest aphid population (199.80) was observed in late sowing (S_3), which was statistically different from other two sowing times. This was followed by (147.37) aphid population observed in S_2. On the other hand, the lowest aphid population (105.71) was recorded in S_1.

From the above findings it was revealed that the early sowing (S_1) manifested the lowest aphid population on mustard inflorescence (105.71) and the highest aphid population was recorded at late sowing of mustard seed.This result was in agreement with those of Cannon, (1998), Bale *et al*. (2002).

4.8. Effect of mustard varieties on aphid population

Significant variations were observed among eight mustard varieties on aphid population at different days after sowing (Table 8). In case of 42 DAS, the highest aphid population (179.7) was recorded in mustard varieties V_1 (Tori-7), which was statistically different from all other varieties. This was followed by (160.6) population in V_8 (160.6) followed by V_3 (140.6) and V_6 (133.1). On the other hand, the lowest aphid population (82.13) was recorded in V_5 (BARI Sharisha-13), which was followed by V_4 (82.63), V_2 (107.1) and V_7 (119.8). More or less similar trends of results were observed at both 49 DAS and 56 DAS. In case of 49 DAS, the highest aphid population (211.3) was recorded on V_1 (Tori-7), which was statistically different from all other mustard varieties. This was followed by V_3 (203.9), V_4 (163.7) and V_8 (145.3). On the other hand, the lowest aphid population (102.6) was recorded in V_5 (BARI Sharisha-13), which was followed by V_2 (116.3), V_7 (118.4) and V_6 (132.4).

Similarly, in case of 56 DAS, the highest aphid population (217.5) was recorded in V_1 (Tori-7), which was statistically different from all other mustard varieties. This was followed by V_3 (211.3), V_6 (187.5) and V_8 (165.8). On the other hand, the lowest aphid population (113.1) was recorded in V_5 (BARI Sharisha-13), which was followed by V_7 (124.8), V_2 (138.4) and V_4 (193.3).

Considering the mean infestation, the highest aphid population (202.83) was observed in V_1 (Tori-7), which was statistically different from other seven mustard varieties. On the other hand, the lowest population (99.28) was recorded in V_5 (BARI Sharisha-13).

Table 8. Effect of variety on the incidence of aphid at different days after sowing (DAS)

Treatments	Aphid population (No./top 10 cm inflorescence) at			
	42 DAS*	49 DAS*	56 DAS*	Mean
V_1 (Tori-7)	179.7 a	211.3 a	217.5 a	202.83 a
V_2 (BARI Sharisha-6)	107.1 e	116.3 e	138.4 d	120.60 e
V_3 (BARI Sharisha-9)	140.6 c	203.9 a	211.3 a	185.26 b
V_4 (BARI Sharisha-11)	82.63 f	163.7 b	193.3 b	146.54 d
V_5 (BARI Sharisha-13)	82.13 f	102.6 f	113.1s f	99.28 f
V_6 (BARI Sharisha-14)	133.1 c	132.4 d	187.5 b	151.0 d
V_7 (BARI Sharisha-15)	119.8 d	118.4 e	124.8 e	121.0 e
V_8 (BARI Sharisha-16)	160.6 b	145.3 c	165.8 c	157.23 c
$LSD_{(0.01)}$	9.38	12.56	7.79	5.67
CV (%)	4.54	5.06	3.04	3.47

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

From this above findings it was revealed that the mustard varieties V_5 (BARI Sharisha-13) had the lowest (99.28) aphid population followed by V_7 (BARI Sharisha-15), where V_1 (Tori-7) manifested highest aphid population (202.83). Considering the rate of aphid infestation, the order of aphid population among highest mustard varieties is $V_1>V_3>V_8>V_6>V_4>V_7>V_2>V_5$. About similar works also done by several workers. Hussain and Begum (1984) reported that Tori-7 are highest susceptible to aphid and BINA-M-46, M-248 and R-5 are resistant or tolerant to the aphid.

4.9. Interaction effect of sowing time and mustard varieties on aphid population

Interaction effect of sowing time and varietyshowed significant variations in aphid population at different days after sowing of mustard seeds (Table 9). In case of 42 DAS,

the highest aphid population (244.0) was recorded in V_1 (Tori-7) sown in S_3 (late sowing time), which was followed by 239.9 aphid population in V_8 sown in S_3 followed by 221.9 aphid population in V_7 sown in S_1. On the other hand, the lowest aphid population (44.60) was in mustard variety V_5 sown in S_1, this was followed by 49.30 aphid population in V_4 sown in S_1.

Table 9. Interaction effect of sowing time and variety on the incidence of aphid of mustard at different days after sowing

Sowing time	Variety	Aphid population (No./top 10 cm inflorescence) at			
		42 DAS*	49 DAS*	56 DAS*	Mean
S_1	V_1	87.70 i	110.6 ij	117.3 k	105.20 l
	V_2	61.30 l	175.0 f	266.8 e	167.70 i
	V_3	80.10 i-k	91.00 k	117.1 k	96.06 n
	V_4	49.30 mn	68.20 l	76.70 m	64.73 q
	V_5	44.60 n	55.90 m	66.00 n	55.50 r
	V_6	111.7 g	193.2 e	257.1 f	187.30 g
	V_7	221.9 b	195.6 e	306.7 b	241.40 c
	V_8	156.2 d	70.30 l	159.5 i	128.67 k
S_2	V_1	71.47 k	71.63 l	73.70 m	72.27 p
	V_2	81.70 ij	149.3 h	266.1 e	165.70 i
	V_3	130.1 e	175.7 f	264.9 e	190.23 f
	V_4	73.10 jk	115.3 i	115.6 k	101.33 m
	V_5	126.9 e	155.1 gh	260.6 e	180.87 h
	V_6	100.7 h	226.9 c	254.7 f	194.10 f
	V_7	239.5 a	143.6 h	283.3 c	220.13 e
	V_8	207.5 c	175.1 f	180.8 g	187.80 g
S_3	V_1	244.0 a	300.8 a	350.6 a	298.47 a
	V_2	116.3 fg	171.8 f	182.3 h	156.80 j
	V_3	58.00 lm	98.30 jk	142.3 j	99.53 n
	V_4	121.1 ef	172.5 f	183.9 h	159.70 j
	V_5	71.70 k	89.10 k	117.3 k	92.70 o
	V_6	200.6 c	209.0 d	274.8 d	228.13 d
	V_7	121.6 ef	164.5 fg	277.3 d	187.80 g
	V_8	239.9 a	265.0 b	280.6 c	261.83 b
$LSD_{(0.01)}$		9.38	12.56	7.79	5.02
CV (%)		4.54	5.06	3.04	2.37

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

[S_1=Seeds sown in 9 November, 2013; S_2= Seeds sown in 16 November 2013 and S_3=Seeds sown in 23 November, 2013. V_1=Tori-7, V_2=BARI sharisha-6, V_3=BARI sharisha-9, V_4=BARI sharisha-11, V_5=BARI sharisha-13, V_6=BARI sharisha-14, V_7 =BARI sharisha-15 and V_8=BARI sharisha-16.]

More or less similar trends of results were observed in 49 DAS and 56 DAS. But the rate of aphid population was increased with increase of plant ages.

From the above findings it was revealed that the V_5 (BARI Sharisha-13) manifested the lowest aphid population (55.50) when it was sown early (S_1) and conversely, the V_1 (Tori-7) manifested the highest aphid population (298.47) by aphids when it was sown in late (S_3). Husain and Begum (1984) also evaluated that Tori-7 variety was highly susceptible to Aphid infestation.

4.10. Effect of sowing time on the number of siliqua per plant

Significant variations were observed among three sowing time of mustard on number of total siliqua per plant (Table 10). The highest total siliqua (145.7) was observed in S_2(16 November) and followed by (128.1) that was recorded at S_3 (23 November). The lowest total siliqua (118.5) was recorded at S_1 (9 November).

4.11. Effect of mustard varieties on the number of siliqua per plant

Significant variations were observed among eight mustard varieties on number of total siliqua per plant (Table 11). The highest total number (159.7) of siliqua per plant was recorded on V_5 (BARI sharisha-13), which was statistically different from all other mustard varieties. This was followed by V_8 (157.1), V_4 (142.9) and V_3 (138.3). On the other hand, the lowest total number (84.83) of siliqua per plant was recorded in V_6 (BARI sharisha-14), which was followed by V_7 (112.4), V_2 (124.9) and V_1 (126.1). As a result, the trend of results in terms of total siliqua among eight mustard varieties is $V_5>V_8>V_4>V_3>V_1>V_2>V_7>V_6$.

4.12. Interaction effect of sowing time and variety on the number of siliqua per plant

Interaction effect of sowing time and varietyshowed significant variation in number of total siliqua per plant (Table 12). The highest total siliqua (222.3) was recorded from the combination of 9 November with BARI sharisha-13 (S_1V_5) treatment. On the other hand, the lowest total siliqua (58.70) was observed from the combination of 23 November with Tori-7 (S_3V_1) treatment.

4.13. Effect of sowing time on the infestation of siliqua by aphids

Significant variations were observed among three sowing time of mustard on number of infested siliqua per plant by aphids (Table 10). The highest infested siliqua (103.3) was observed in S_3(23 November) and followed by (86.90) that was recorded at S_1 (9 November). The lowest infested siliqua (80.80) was recorded at S_2 (16 November).

4.14. Effect of mustard varieties on the infestation of siliqua by aphids

Significant variations were observed among eight mustard varieties on the number of infested siliqua per plant by aphids (Table 11). The highest infested siliqua (122.5) by aphid was recorded on V_3 (BARRI sharisha-9), which was statistically different from all other mustard varieties. This was followed by V_8 (120.0), V_4 (110.8) and V_1 (91.00). On the other hand, the lowest infested siliqua (62.23) by aphid was recorded in V_5 (BARI sharisha-13), which was followed by V_6 (62.87), V_2 (65.99) and V_7 (87.23). As a result, the trend of results in terms of infested siliqua among eight mustard varieties is $V_3>V_8>V_4>V_1>V_7>V_2>V_6>V_5$.

4.15. Interaction effect of sowing time and variety on infested siliqua by aphids

Interaction effect of sowing time and varietyshowed significant variation on number of infested siliqua per plant by aphid (Table 12). The highest infested siliqua (163.3) was recorded from the combination of 9 November with BARI sharisha-15 (S_1V_7) treatment. On the other hand, the lowest infested siliqua (53.30) was observed from the combination of 9 November with BARI sharisha-16 (S_1V_8) which was statistically similar with S_3V_1 (57.50) treatment.

4.16. Effect of sowing time on infestation intensity of siliqua by aphids

Significant variations were observed at 65 DAS among three sowing time of mustard on the percentage of siliqua infestation intensity by aphids (Table 10). The highest siliqua infestation intensity (79.87%) was observed in S_3(23 November) and followed by (76.26%) that was recorded at S_1 (9 November). The lowest siliqua infestation intensity (62.92%) was recorded at S_2 (16 November).

Table 10. Effect of sowing time on the siliqua infestation by aphid

Treatments	Total siliqua (No./plant)	Infested siliqua (No./plant)	Siliqua infestation intensity (%)
S_1 (9 November)	118.5 c	86.90 b	76.26 b
S_2 (16 November)	145.7 a	80.80 c	62.92 c
S_3 (23 November)	128.1 b	103.3 a	79.87 a
$LSD_{(0.01)}$	2.49	2.06	2.50
CV (%)	1.89	2.87	3.41

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD test at 0.01 level of probability.

4.17. Effect of mustard varieties on siliqua infestation intensity by aphids

Significant variations were observed among eight of mustard varieties on the percentage of siliqua infestation intensity by aphids (Table 11). The highest siliqua infestation intensity (90.87%) by aphid was recorded on V_3 (BARI sharisha-9), which was statistically different from all other mustard varieties. This was followed by V_4 (79.53%), V_7 (77.37%) and V_6 (77.27%). On the other hand, the lowest siliqua infestation intensity (44.20%) by aphids was recorded in V_5 (BARI sharisha-13), which was followed by V_2 (66.41%), V_1 (72.35%) and V_8 (76.14%). As a result, the trend of results in terms of siliqua infestation intensity among eight mustard varieties is $V_3 > V_4 > V_7 > V_6 > V_8 > V_1 > V_2 > V_5$.

Table 11. Effect of variety on the siliqua infestation by aphid at 65 days after sowing

Treatments	Total siliqua (No./plant)	Infested siliqua (No./plant)	Siliqua infestation intensity (%)
V_1 (Tori-7)	126.1 d	91.00 c	72.35 c
V_2 (BARI Sharisha-6)	124.9 d	65.99 d	66.41 d
V_3 (BARI Sharisha-9)	138.3 c	122.5 a	90.87 a
V_4 (BARI Sharisha-11)	142.9 b	110.8 b	79.53 b
V_5 (BARI Sharisha-13)	159.7 a	62.23 d	44.20 e
V_6 (BARI Sharisha-14)	84.83 f	62.87 d	77.27 b
V_7 (BARI Sharisha-15)	112.4 e	87.23 c	77.37 b
V_8 (BARI Sharisha-16)	157.1 a	120.0 a	76.14 bc
$LSD_{(0.01)}$	4.07	4.25	4.09
CV (%)	1.89	2.87	3.41

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

4.18. Interaction effect of sowing time and variety on siliqua infestation intensity by aphids

Interaction effect of sowing time and varietyshowed significant variation on the percentage of siliqua infestation intensity by aphids (Table 12). The maximum siliqua infestation intensity (97.96%) was recorded from the combination of 23 November with Tori-7 (S_3V_1) which was statistically similar with S_1V_7 (95.52%) treatment. On the other hand, the minimum siliqua infestation intensity (19.67%) was observed from the combination of 9 November with BARI sharisha-13 (S_1V_5) treatment.

Table 12. Interaction effect of sowing time and variety on the siliqua infestation by aphid at 65 days after sowing

Sowing time	Variety	Total siliqua (No./plant)	Infested siliqua (No./plant)	Siliqua infestation intensity (%)
S_1	V_1	114.2 l	79.70 hi	69.78 h
	V_2	198.3 c	136.7 c	68.93 h
	V_3	110.4 lm	82.70 gh	74.88 g
	V_4	205.3 b	49.30 n	24.02 l
	V_5	222.3 a	43.70 o	19.67 m
	V_6	150.0 h	106.7 e	71.11 gh
	V_7	171.0 e	163.3 a	95.52 ab
	V_8	104.7 n	53.30 mn	50.94 j
S_2	V_1	80.50 p	67.00 k	83.21 ef
	V_2	135.7 i	58.30 l	42.97 k
	V_3	166.4 f	138.3 c	83.13 ef
	V_4	185.3 d	146.7 b	79.14 f
	V_5	65.80 q	60.30 l	91.64 bc
	V_6	127.7 j	109.3 e	85.64 de
	V_7	138.0 i	118.0 d	85.51 de
	V_8	118.5 k	101.0 f	85.23 de
S_3	V_1	58.70 r	57.50 lm	97.96 a
	V_2	84.00 p	75.00 j	89.23 cd
	V_3	136.3 i	84.00 g	61.61 i
	V_4	92.30 o	77.67 ij	84.15 e
	V_5	108.3 mn	78.00 ij	72.00 gh
	V_6	89.00 o	81.67 g-i	92.00 bc
	V_7	121.0 k	84.70 g	69.97 h
	V_8	155.0 g	115.0 d	74.19 g
$LSD_{(0.01)}$		4.07	4.25	4.09
CV (%)		1.89	2.87	3.41

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

[S_1=Seeds sown in 9 November, 2013; S_2= Seeds sown in 16 November 2013 and S_3=Seeds sown in 23 November, 2013. V_1=Tori-7, V_2=BARI sharisha-6, V_3=BARI sharisha-9, V_4=BARI sharisha-11, V_5=BARI sharisha-13, V_6=BARI sharisha-14, V_7 =BARI sharisha-15 and V_8=BARI sharisha-16.]

4.19. Effect of sowing time on plant related yield attributes

4.19.1. Effect of sowing time on plant height

Statistically significant differences were found for plant height of mustard due to sowing time (Table 13). The maximum plant height (106.0 cm) was recorded from S_1 (9 November) whereas, the minimum (86.80 cm) was observed from S_3 (23 November) which was statistically identical (88.21 cm) with S_2 (16 November).

4.19.2. Effect of sowing time on pod length

Pod length of mustard differed significantly due to sowing time (Table 13). The maximum pod length (8.08 cm) was recorded from S_1 (9 November) whereas, the minimum (6.00 cm) was recorded from S_3 (23 November) which was followed by S_2 (6.47 cm).

4.19.3. Effect of sowing time on number of seeds/pod

Number of seeds/pod of mustard at maturity differed significantly due to sowing time (Table 13). The highest seeds/pod (21.30) was recorded from S_1 (9 November). On the other hand, the lowest seeds/pod (17.96) was found in S_3 (23 November) which was statistically identical (18.73) with S_2 (16 November).

Table 13. Effect of sowing time on yield contributing characteristics of mustard

Treatments	Plant height (cm)	Pod length (cm)	Number of seeds/pod
S_1 (9 November)	106.0 a	8.08 a	21.30 a
S_2 (16 November)	88.21 b	6.47 b	18.73 b
S_3 (23 November)	86.80 b	6.00 c	17.96 b
$LSD_{(0.01)}$	1.80	0.18	1.86
CV (%)	1.91	2.73	9.61

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD test at 0.01 level of probability.

Similar result was also observed by Shrivastava (1999) and Vekaria and Patel (2000) that late sowing results higher aphid infestation which hamper yield contributing characteristics

4.20. Effect of mustard variety yield attributes

4.20.1. Effect of mustard variety on plant height

Plant height of mustard differed significantly due to varieties (Table 14). The maximum plant height (102.7 cm) was recorded from V_5 (BARI sharisha-13) and followed by V_7 (97.83 cm) and V_2 (97.73 cm). On the other hand, the minimum plant height (88.27 cm) was recorded from V_1 (Tari-7) which was statistically identical with V_3 (89.70 cm), V_6 (89.77 cm), V_8 (90.10 cm).

4.20.2. Effect of varieties on pod length

Statistically significant differences were found for pod length of mustard due to varieties (Table 14). The maximum pod length (9.50 cm) was recorded from V_5 (BARI sharisha-13) which was followed by V_6 (7.56 cm) and V_2 (7.40 cm). On the other hand, the minimum pod length (5.86 cm) was observed from V_4 (BARI sharisha-11) which was followed by V_1 (6.00 cm), V_3 (6.06 cm), V_7 (6.20 cm) and V_8 (6.25 cm).

4.20.3. Effect of mustard variety on number of seeds/pod

Statistically significant differences were found for number of seeds/pod of mustard due to varieties (Table 14). The highest seeds/pod (26.87) was recorded from V_5 (BARI sharisha-13) which was statistically identical with V_2 (25.37) and V_6 (24.10). On the other hand, the lowest seeds/pod (12.93) was recorded from V_4 (BARI sharisha-11) which was statistically similar with V_3 (15.00), V_1 (15.07) and V_8 (16.27).

Table 14. Effect of variety on yield contributing characteristics of mustard

Treatments	Plant height (cm)	Pod length (cm)	Number of seeds/pod
V_1 (Tori-7)	88.27 d	6.00 cd	15.07 cd
V_2 (BARI Sharisha-6)	97.73 b	7.40 b	25.37 a
V_3 (BARI Sharisha-9)	89.70 d	6.06 cd	15.00 cd
V_4 (BARI Sharisha-11)	93.23 c	5.86 d	12.93 d
V_5 (BARI Sharisha-13)	102.7 a	9.50 a	26.87 a
V_6 (BARI Sharisha-14)	89.77 d	7.56 b	24.10 a
V_7 (BARI Sharisha-15)	97.83 d	6.20 c	19.03 b
V_8 (BARI Sharisha-16)	90.10 d	6.25 c	16.27 bc
$LSD_{(0.01)}$	2.93	0.30	3.05
CV (%)	1.91	2.73	9.61

*DAS = Days after sowing. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

4.21. Interaction effect of sowing time and variety on yield attributes

4.21.1. Interaction effect of sowing time and variety on plant height

Interaction effect of sowing time and varietyshowed significant variation in plant height (Table 15). The highest plant height (138.80 cm) was recorded from the combination of 9 November with BARI sharisha-13 (S_1V_5) treatment whereas, the lowest (70.00 cm) was observed from the combination of 23 November with BARI sharisha-6 (S_3V_2) treatment which was statistically identical with S_3V_8 (71.20 cm) and S_3V_7 (72.00 cm).

4.21.2. Interaction effect of sowing time and variety on pod length

Interaction effect of sowing time and varietyshowed significant variation in pod length of mustard (Table 15). The maximum pod length (12.00 cm) was recorded from the combination of 9 November with BARI sharisha-13 (S_1V_5) treatment whereas, the minimum (5.00 cm) was observed from the combination of 23 November with Tori-7 (S_3V_1) treatment which was statistically similar with S_1V_2 (5.20 cm).

4.21.3. Interaction effect of sowing time and variety on number of seeds/pod

Interaction effect of sowing time and varietyshowed significant variation in number of seeds/pod of mustard (Table 15). The maximum seeds/pod (29.70) was recorded from the combination of 9 November with BARI sharisha-13 (S_1V_5) treatment whereas, the minimum (10.90) was observed from the combination of 23 November with Tori-7 (S_3V_1) treatment which was statistically similar with S_2V_3 (12.10), S_1V_2 (13.30) and S_3V_3 (13.30).

Table 15. Interaction effect of sowing time and variety on yield contributing characteristics of mustard

Sowing time	Variety	Plant height (cm)	Pod length (cm)	Number of seeds pod^{-1}
S_1	V_1	98.20 gh	6.50 f-h	17.70 de
	V_2	100.5 fg	5.20 lm	13.30 g-i
	V_3	124.1 c	5.80 jk	17.90 de
	V_4	131.9 b	10.20 c	26.30 b
	V_5	138.8 a	12.00 a	29.70 a
	V_6	115.5 d	6.80 f	18.80 d
	V_7	110.3 e	6.60 fg	15.40 e-g
	V_8	103.3 f	6.60 fg	18.80 d
S_2	V_1	81.50 mn	5.50 kl	13.30 g-i
	V_2	82.70 k-m	10.90 b	25.70 b
	V_3	83.60 k-m	6.00 fg	12.10 hi
	V_4	94.70 i	6.40 gh	18.70 d
	V_5	96.00 hi	9.70 d	27.00 ab
	V_6	85.10 kl	6.20 hi	14.20 f-h
	V_7	85.60 jk	5.60 k	11.30 hi
	V_8	88.10 j	5.50 kl	16.80 d-f
S_3	V_1	64.10 p	5.00 m	10.90 i
	V_2	70.00 o	6.40 gh	26.50 b
	V_3	81.50 mn	5.50 kl	13.30 g-i
	V_4	93.60 i	6.80 f	14.20 f-h
	V_5	95.90 hi	7.30 e	22.40 c
	V_6	78.80 n	6.00 ij	24.10 bc
	V_7	72.00 o	5.60 k	25.20 bc
	V_8	71.20 o	5.96 ij	17.90 de
$LSD_{(0.05)}$		2.93	0.30	3.05
CV (%)		1.91	2.73	9.61

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

[S_1=Seeds sown in 9 November, 2013; S_2= Seeds sown in 16 November 2013 and S_3=Seeds sown in 23 November, 2013. V_1=Tori-7, V_2=BARI sharisha-6, V_3=BARI sharisha-9, V_4=BARI sharisha-11, V_5=BARI sharisha-13, V_6=BARI sharisha-14, V_7 =BARI sharisha-15 and V_8=BARI sharisha-16.]

4.22. Effect of sowing time on grain yield of mustard

Significant variations were observed among three sowing time of mustard on yield per plot (Table 16). The highest yield (144.50 g) was observed in S_1(9 November). The lowest yield (54.19 g) was recorded at S_3 (23 November) and followed by (66.58 g) that was recorded at S_2 (16 November). Significant variations were observed among three

sowing time of mustard on yield per hectare (Table 16). The highest yield (467.40 kg) was observed in S_1(9 November). The lowest yield (233.80 kg) was recorded at S_3 (23 November) and followed by (258.80 kg) that was recorded at S_2 (16 November).

Table 16. Effect of sowing time on yield of mustard

Treatments	Yield (g plot^{-1})	Yield (kg ha^{-1})
S_1 (9 November)	144.5 a	467.4 a
S_2 (16 November)	66.58 b	258.8 b
S_3 (23 November)	54.19 c	233.8 c
$LSD_{(0.01)}$	1.86	8.67
CV (%)	2.09	2.69

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD test at 0.01 level of probability.

Same type of results were also observed by Tapas *et al*., 2007,that the early sown crop almost escaped the aphid attacks in all the growth stages of the crop and resulted higher yield compare to late sown crop

4.23. Effect of varieties on grain yield of mustard

Significant variations were observed among eight of mustard varieties on yield per plot (Table 17). The highest yield (102.22 g/plot) was recorded on V_5 (BARI sharisha-13), which was statistically different from all other mustard varieties. This was followed by V_2 (97.52 g), V_7 (76.33 g) and V_6 (93.00 g). On the other hand, the lowest yield (70.11 g) was recorded in V_1 (Tori-7), which was followed by V_8 (71.67 g), V_3 (79.85 g) and V_4 (91.18 g/plot). Similarly, significant variations were observed among eight of mustard varieties on yield per hectare (Table 17). The highest yield (562.30 kg/ha) was recorded on V_5 (BARI sharisha-13), which was statistically different from all other mustard varieties. This was followed by V_7 (398.40 kg) and V_6 (375.40 kg). On the other hand, the lowest yield (200.80 kg) was recorded in V_1 (Tori-7), which was followed by V_8 (204.80 kg) and V_3 (210.30 kg/ha).

Table 17. Effect of variety on yield of mustard

Treatments	Yield (g plot^{-1})	Yield (kg ha^{-1})
V_1 (Tori-7)	70.11 e	200.8 f
V_2 (BARI Sharisha-6)	97.52 b	319.4 d
V_3 (BARI Sharisha-9)	79.85 d	210.3 f
V_4 (BARI Sharisha-11)	91.81 c	288.5 e
V_5 (BARI Sharisha-13)	102.22 a	562.3 a
V_6 (BARI Sharisha-14)	93.00 b	375.4 c
V_7 (BARI Sharisha-15)	96.33 b	398.4 b
V_8 (BARI Sharisha-16)	71.67 e	204.8 f
$LSD_{(0.01)}$	3.04	14.16
CV (%)	20.9	2.69

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

Similar works was also done by several workers. Hussain and Begum (1984) reported that Tori-7 and YS-67 are highly susceptible to aphid and BINA-M-46, BINA-M-59, M-248 and R-5 are resistant or tolerant to the aphid.

4.24. Interaction effect of sowing time and varieties on grain yield of mustard

Interaction effect of sowing time and varietyshowed significant variation in yield per plot of mustard (Table 18). The maximum yield (217.0 g/plot) was recorded from the combination of 9 November with BARI sharisha-13 (S_1V_5) treatment whereas, the minimum (14.0 g) was observed from the combination of 23 November with Tori-7 (S_3V_1) and 23 November with BARI sharisha-6 (S_3V_2) treatment.

Similarly, considering yield per hectare, the highest yield (775.0 kg) was recorded from the combination of 9 November with BARI sharisha-13 (S_1V_5) treatment. On the other hand, the lowest yield (50.0 kg) was observed from the combination of 23 November with Tori-7 (S_3V_1) treatment which was statistically similar with S_2V_2 (57.14 kg) treatment (Table 18).

Table 18. Interaction effect of sowing time and variety on yield of mustard

Sowing time	Variety	Yield (g plot^{-1})	Yield (kg ha^{-1})
S_1	V_1	97.00 h	142.9 n
	V_2	95.33 h	286.9 j
	V_3	85.67 i	546.4 c
	V_4	153.0 c	554.8 c
	V_5	217.0 a	775.0 a
	V_6	126.7 e	340.5 h
	V_7	78.55 j	194.1 l
	V_8	67.00 k	239.3 k
S_2	V_1	39.22 n	57.14 p
	V_2	40.00 n	459.5 e
	V_3	48.33 m	147.6 n
	V_4	147.0 d	358.3 g
	V_5	198.0 b	707.1 b
	V_6	114.4 f	416.7 f
	V_7	54.22 l	171.4 m
	V_8	48.00 m	123.8 o
S_3	V_1	14.00 p	50.00 p
	V_2	14.00 p	179.8 m
	V_3	33.55 o	306.0 i
	V_4	125.8 e	172.6 m
	V_5	155.3 c	525.0 d
	V_6	100.3 g	346.4 gh
	V_7	34.67 o	452.4 e
	V_8	35.33 o	126.2 o
$LSD_{(0.01)}$		3.04	14.16
CV (%)		2.09	2.69

*DAS = Days after sowing; In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by DMRT at 0.01 level of probability.

[S_1=Seeds sown in 9 November, 2013; S_2= Seeds sown in 16 November 2013 and S_3=Seeds sown in 23 November, 2013. V_1=Tori-7, V_2=BARI sharisha-6, V_3=BARI sharisha-9, V_4=BARI sharisha-11, V_5=BARI sharisha-13, V_6=BARI sharisha-14, V_7 =BARI sharisha-15 and V_8=BARI sharisha-16.]

CHAPTER V

SUMMARY AND CONCLUSION

The present study was conducted on suitable sowing time and varietal screening of mustard against aphid, *Lipaphiserysimi* (Kalt.). The research work was conducted during the period from November 2013 to February 2014 (Rabi season) at the Research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh. Abundance and aphid infestation, yield and yield attributes were studies to identify the resistance source(s) among eight mustard varieties with three sowing times.

SUMMARY

Considering the abundance of aphid infested plant and inflorescence, the BARI Sharisha-13 can be identified as least preferred host to mustard aphid with early sowing time 9 November. The variety Tori-7 and BARI Sharisha-9 can be identified as most preferred host to aphid infestation. The percent plant infestation was sharply increased with the increased of the plants age and sowing time. The order of trend in the mean incidence of aphid infested plant among eight mustard varieties is Tori-7>BARI Sharisha-9> BARI Sharisha-14> BARI Sharisha-11> BARI Sharisha-16> BARI Sharisha-15> BARI Sharisha-6> BARI Sharisha-13.

In respect of incidence of aphid population, among eight varieties of mustard, Tori-7 performed as the most preferred host followed by BARI Sharisha-9, whereas BARI Sharisha-13, BARI Sharisha-6 and BARI Sharisha-15 performed as least preferred host for mustard aphid in terms of incidence of aphid population by number per plant. On the other hand, late sowing time performed as the most preferred condition and early sowing time performed as least preferred environment for mustard aphid. The order of trend in the mean incidence of aphid population among eight mustard varieties is Tori-7>BARI Sharisha-9> BARI Sharisha-16> BARI Sharisha-14> BARI Sharisha-11> BARI Sharisha-15> BARI Sharisha-6> BARI Sharisha-13.

Considering the percentage of infested siliqua by aphid infestation, the highly susceptible variety Tori-7 produced higher percentages (72.35%) of infested siliqua due to attack by the higher number aphids. Conversely, BARI Sharisha-13 produced lower percentage (44.20%)of deformed siliqua because of the lower incidence of the aphid population.

In case of influence of the aphid infestation on the yield attributes, among eight mustard varieties, BARI Sharisha-13 with sown in 9 November was the best in all aspects of yield attributes. The variety Tori-7 with sowing time in 23 November is the least performance in all aspects of yield attributes and trend is Tori-7>BARI Sharisha-9> BARI Sharisha-16> BARI Sharisha-14> BARI Sharisha-11> BARI Sharisha-15> BARI Sharisha-6> BARI Sharisha-13.

CONCLUSION

Considering the findings of the present study it can be concluded as below:

- Early sowing date ie, 9 November was identified as the most effective sowing time of mustard seeds to escape from aphid infestation than 16 and 23 November
- Among eight mustard varieties, BARI Sharisha-13 was identified as the least preferred host to mustard aphid in terms of the lowest incidences of aphids infestation on plant, inflorescence, and pods.
- The variety Tori-7 and BARI Sharisha-9 were identified as most preferred host to aphid infestation.
- BARI Sharisha-13 sown at early season (9 November) produced the best yield attributes and yield of mustard.
- The variety Tori-7 sown at late season (23 November) produced the least yield attributes and yield of mustard than other varieties and sowing times.

RECOMMENDATIONS

- Early sowing time (9 November) for mustard cultivation can be recommended to escape the aphid infestation on mustard.
- BARI Sharisha-13 can be recommended as the least preferred variety against mustard aphid as well as to produce maximum grain yield.
- BARI Sharisha-13 sown at early season (9 November) produce maximum grain yield of mustard.
- Further intensive study can be done in different agro-ecological zones of Bangladesh with the incorporation other available mustard varieties and genotypes.

CHAPTER VI

REFERENCES

Agarwal, N., Rohilla, H.R. and Singh, H. (1996a). Evaluation of rape seed mustard genotypes against mustard aphid, *Lipaphiserysimi* (Kalt.) at inflorescence stage. *Ann. Biol.***12**(1): 93-95.

Agarwal, N., Rohilla, H.R. and Singh, H. (1996b). Influence on crop morpho-phenological and metrological parameters on the field infestation of mustard aphid in mustard plants. *Environ. Ecol.***14**(2): 268-272.

Ahmed, M.U., Ahmed, A. and Mannan, M.A. (1977).Studies on the comparative effectiveness of organo-phosphorus insecticides for the control of mustard aphid in Bangladesh.*Bangladesh J. Agric. Res.***11**(2): 16-19.

Ahuja, D.B. (1990). Population dynamics of mustard aphid on Indian mustard.*Indian J. Plant Prot.***18**(2): 233-234.

Alam, M.Z., Ahmed, A. and Siddique, A. (1964).Control of winter aphids in East Pakistan. A Review of Research Division of Entomology, 1947-1964. *Agric. Inform. Serv.***3**: 256-259.

Amjad, M. and Peters, D.C. (1992).Survival, development and reproductive of turnip aphid on oilseeds.*J. Econ. Entomol.***85**(5): 2003-2007.

Angrej, S., Dhingra, K.K., Jagroop, S. and Singh, M.P. (2002). Effect of sowing time and plant density on growth, yield and quality of mustard.*J. Res. Punjab Agril. Univ.***39**(4): 471-475.

Anonymous. (1995). Assessment of losses due to aphid infestation at different growth of mustard, Ann. Rep.1994-1995, Bangladesh Agric. Inst., Reginal Agric. Res. Station. p.120.

Ansari, H.S., Qayyum, K.K. and Singh, M.P. (1990).Effcet of different sowing time on the growth and yield of three varieties of mustard.*Pakistan J. Agric. Res.***11**(4): 234-384.

Atwal, A.S., Chaudhary, J.P. and Ramajan, M. (1976).Pest of oilseed crops.Agricultural pests of India and South East Asia.Kalyani Publishers, New Delhi, pp. 296-298.

Bakhetia, D.R.C. (1983). Losses in rapeseed and mustard due to aphid in India.*In:* A literature study proceeding of with international Rapeseed conference held at paris from 17-19 May, 1983.

Bakhetia, D.R.C. and Iabana, K.S. (1978).Insect resistance in *Brassica* crops.Crop Improvement.**5**(2): 95-103.

Balwant, S., Gupta, S.K. and Kotwal, D.R. (2004).Screening of some mustard species and their strains for resistance to mustard aphid based on aphid infestation.*Evniron. Ecol*.**22**(3): 565-568.

BARC.(1999). Fertilizer recommendation Guide. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215. p. 196.

Anonymous. (2012).Status of oil crop production in Bangladesh, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

Bassvaraju, B.S., Rajgopal, B.K., Rajgopal, D. and Sheriff, R.A. (1994).Biology of mustard aphid in South India.*Mysore J. Agric. Sci*.**28**(2): 132-138.

Begum, M. (1988).Comparative study on the susceptibility of different genotypes of mustard to aphid. M.S. Thesis, Department of Entomology, Bangladesh Agricultural University, Mymensingh. p. 64.

Begum, S. (1994). Assessment of losses due to aphid infestation at different crop growth stages at Joydebpur. Annual Research Report (1993-1994). Entomol.Div., BARI, Joydebpur, GAzipur. pp. 30-31.

Begum, S. (1995). Population activities of mustard aphids in relation to different sowing time, Annual Research Report 1994-1995.Entomol.Div., BARI, Joydebpur, GAzipur. pp. 30-31.

Bhadauria, N.S., Jakhmola, S.S. and Dhamdhere, S.V. (1995).Relative susceptibility of mustard cultivars to aphid in North-west Madhya Pradesh, India.*J. Entomol. Res.***19**(2): 143-146.

Bhat, G.N., Wani, A.R. And Ansari, I.A. (2004).Screening of mustard varieties against mustard aphid.*Shashpa.***11**(1): 79-81.

Biswas, G.C. and Das, G.P. (2000).Population dynamics of the mustard aphid.*Bangladesh J. Entomol.***10**(1 & 2): 15-22.

Brar, K.S. and Sandhu, G.S. (1987).Comparative resistance of different mustard species to the mustard aphid under natural and artificial condition.*Indian.Agril. Res.***12**(3): 198-200.

Brar, K.S., Ratual, H.S. and Lobana, K.S. (1976).Different of mustard aphid to different rapeseed and mustard varieties under natural and artificial infestation.*J. Res. Punjab Agril. Univ.***13**(1): 14-18.

Buttar, G.S. and Aulakh, C.S. (1999). Effect of sowing dates, nitrogen and raw spacing on growth, yield and quality of Indian mustard. *Indian J. Agron.***44**(4): 813-815.

Dixon, A.F.C. (1987). Parthenganetic reproduction and rate of increase in aphid pp. 169-187.

Eastop, V.F. (1961). A study of the Aphiiddae of West Africa. William Clowes and Sons Ltd., London. p. 93.

FAO (Food and Agricultural Organization).(2011). Production Yearbook for 2009.FAO, UN, Rome, Italy.p. 118.

Gomez, K.A. and Gomez, A.A. (1984).Statistical procedure for agricultural research.Second Edn. Intl. Rice Res. Inst., John Wiley and Sons. New York. pp. 1-340.

Ghosh, M.R. (1985). *Aphid Ba Jabpoka* (in Bangla). West Bengal State Book Board, Calcutta. p. 175.

Ghosh, R.K. and Chaterjee, B.N. (1988).Effect of dates of sowing on oil content and fatty acid profiles of Indian mustard.*Indian J. Oilseed. Res.***5**(2): 144-149.

Hill, D.S. (1983). Agricultural Insect Pest of Tropics and their control.Cambridge University press, London.p. 746.

Haider, M., Ahmed, F.P. and Mushtaq, F. (1991) Role of physio-morphic characters imparting resistance in cotton against some insect pests. *Pak. Entomol.***21**: 61-62.

Husain, M. and Begum, N. (1984).Evaluation of mustard varieties for their reaction to aphids.*Bangladesh J. Agric.***9**(4): 31-34.

Husain, M. and Shahjahan, M. (1997).Field and net house evaluation of some mustard varieties for reaction to aphid.*Bangladesh J. Entomol.***7**(2): 27-35.

Islam, N. (1991). Effect of sowing time on the abundance of mustard aphid on the infestation and yield of mustard. Annual Research Report (19990-1991). Entomol.Dis., BARI, Jodebpur, GAzipur. pp. 28-29.

Jaglan, R.S., Singh, R. and Singh, H. (1988).Effect of abiotic factors on the field population of mustard aphid.*Indian J. Ecol.***15**(2): 163-167.

Kabir, M.H. (1987). Evaluation of some mustard germplasms for their reaction to mustard aphid.M.S. Thesis, Dept. of Entomology, BAU, Mymensingh.p. 64.

Kabir, S.M.H. and Khan, A.H. (1980).The nature of infestation of aphid effects on the growth and yield of mustard crop.Proc.Of 14^{th} and 5^{th} Bangladesh Sci. Conf. pp. 8.

Kalra, U.K., Yadava, T.P. and Bhola, A.L. (1985). Agricultural Science Digest (India) (3-4): 177-178.

Kandil, A.A. (1983). Effect of sowing date on yield components and some agronomic characters of oilseed rape.p. 297.

Kawada, K. (1987). Polymorphism and morph determination. Pp. 255-286.

Kaul, A.K. and Das, M.L. (1986). In: Oilseeds in Bangladesh. Bangladesh-canada-Agriculture Sector Jeam (ed.). Ministry of Agriculture, Bangladesh, Dhaka.p. 49.

Kher, S. and Rataul, H.S. (1992a) Screening of some mustard and their strains for resistance to mustard aphid I based on aphid infestation index.*Indain J. Entomol.***54**(3): 255-261.

Kher, S. and Rataul, H.S. (1992a) Screening of some mustard and their strains for resistance to mustard aphid II based on aphid infestation index.*Indain J. Entomol.***54**(2): 217-221.

Kumar, V., Singh, D., Kamboj, M.C., Pundir, S.R. and Chandra, N. (1994).Genetics of resistance to mustard aphid in India mustard at different stages of crop.*Crop Res. Hisar*.**7**(2): 256-262.

Kundu, R.J.C, Roy, C., Islam, M.N. and Islam, S. (2002). Seasonal trends in the reproductive potential of mustard aphid. *Bangladesh J. Zool*.**30**(2): 135-140.

Kundu, R., Mollah, M.A.H., Khan, M.M.H. and Hossain, M.A. (1997). Strategies on the short-term reproduction effort: A comparison between groundnut aphid and mustard aphid. *Bangladesh J. Ent.***7**(1 & 2): 75-83.

Kuo, M.H. (1999). Effects of temperature, photoperiod and crowding treatment on a late formation in the turnip aphid.*Plant Prot. Bull. Tsipei*.**41**(5): 255-264.

Lal, M.N., Singh, S.S. and Singh, V.P. (1997).Screening of mustard varieties for resistance against mustard aphid.*J. Entomo. Res.***21**(4): 371-375.

Malik, R.S. (1988). Comparative aphid tolerance in cultivated apecies of mustard.*New Botenist.***165**(2 & 3): 113-116.

Malviya, J.K. And Lal, M.N. (2000).Screening of mustard varieties against mustard aphid.*Ann. Plant Prot. Sci*.**8**(2): 150-153.

Martin, J.H. (1983). The identification of common aphid pests of tropical agriculture.*Trop. Pest Manag*.**5**(1): 4-11.

Mohammad, F., Samullah, M.M., Afridi, R.K. and Akhan, N.A. (1984).Morphology of mustard varieties to three sowing dates.*Bangladesh J. Agric. Res.***14**(10): 66-71.

Mondal, N., Alam, M.S., Hasna, F. and Das, D.C. (1992).Effect on food on larval development period of aphid.*Bangladesh J. Zool*.**20**(2): 297-300.

Mondal, M.R.I. and Islam, M.A. (1993).Effect of seed rate and date on yield and yield components of rapeseed.*Bangladesh J. Agril. Sci*.**20**(1): 29-33.

Mondal, R.I., Biswas, M.M.K. and Akbar, M.A. (1999).Response of rapeseed genotype to seed rate and seeding date.*Bangladesh J. Agric. Res.***24**(1): 83-90.

Muller, F.P. and Scholl, S.E. (1958). Some notes on the aphid of South Africa. *J. Ent. Soc. S. Africa.***21**(2): 382-414.

Nasir, A.B., Javed, H., Aslam, M. and Khan, A. (1998). Influence of abiotic factors on the population of mustard aphid. *Sarhad. J. Agric.***14**(5): 453-455.

Pandey, B.P., Srivastava, S.K. and nawal, R.K. (1981).Genotype and environment interaction in lebtil. Pp. 14-17.

Patel, S.R., Sharma, S.K. and Lal, R.S. (2000). Influence of sowing time on the yield of different mustard cultivars under conserved soil moisture condition. *Indian J. Agric. Sci.***70**(6): 398-399.

Phadke, K.G. (1992). Life table and growth studies on aphid in relation to mustard variety.*Indian J. Ent.***44**: 136-144.

Prasad, S.K. and Phadke, K.G. (1987).Identification of mustard genotypes leats susceptible to mustard aphid.*J. Aphidiology.* **1**(1 & 2): 93-97.

Pradhan, S. (1994).Insect pest of crop (3rd edition). National Book Trust, India., p.200.

Prasad, S.K. (1983). Varieties Susceptibility of rapeseed and mustard aphid. *Ann. Agric. Res.***22**(1): 120-122.

Prasad, S.K. (2003). Screening of rapeseed and mustard against mustard aphid.*Indian J. Ent.***54**(4): 501-503.

Rahman, M.M., Salam, M.T. and Patel, J.C. (1980). Effect of different sowing dates,specing and plant population on yield of mustard. *Indian J. Agron.***25**: 256-257.

Rahman, M.M., Hossain, S.M., Islam, A.N. and Salam, M.U. (1993).Effect of sowing date and boron fertilizer on yield and oil content of mustard and rapeseed.*Bangladesh Agron. J.***15**(1): 73-78.

Rahman, M.M. (2012). Status of Oil Seeds and Future Prospects in Bangladesh. p. 34-40.

Rai, HS.,Tiwari, RC. And Shrivastava, RN. (1995). Screening of toria, yellow sarson and rai entries for tolerance against mustard aphid. *Crop. Res. Hisar.***10**(2): 206-208.

Ram, S. and Gupta, M.P. (1987).Effect of weather conditions and time of aowing on the incidence of mustard aphid.BhartiyaKrishiAnusandhanaPatrika. **2**(1): 29-34.

Ram, S., Gupta, M.P. and Mauraya.R.P. (1989).Mustard variety resistance to aphid in India.*Trop. Pest Manage.***35**(2): 150-153.

Rangre, M.A., Baba, M. and Wani, N.A. (2002).Screening of mustard varieties cultivation against mustard aphid.*Appl. Biol. Res.***4**(1/2): 75-77.

Rohilla, H.R., Singh, H., Kalra, V.K. and Kharub, S.S. (1987). Losses caused by mustard aphid in different mustard genotypes. 7th*Int Rapeseed Cong.* Poznan, Poland. pp. 11-14.

Roy J.C., Islam, M.N. and Islam, S. (2002). Seasonal trends in the reproductive potential of mustard aphid. *Bangladesh J. Zool.* **30**(2): 135-140.

Roy, P. (1975). Population dynamics of mustard aphid in West Bengal.*Inian J. Ent.***37**(2): 218-322.

Roy, S.K. and Baral, K. (2001).Effect of infestation by mustard aphid on yield and its attributes.*J. Appl. Biol. Res.***13**(1): 39-43.

Sachan, J.N. and Bansal, O.P. (1975). Influence of different host plants on the biology of mustard aphid. *Indian J. Ent.***37**(4): 420-424.

Saha, C.S. and Kanchan, B. (1999): Effect of dates of sowing and potash levels on incidence of mustard aphid (LiphaphiserysimiKalt.). – Environment Ecology, 17(1): 211-215.

Sahira, D. (1982). The effect of different plant parts on development, reproductive and longevity in aphid.*J. Res. Assam. Agril. Univ.***3**: 67-71.

Samdur, M.Y., Gulati, S.C., Rajni, R. and Manivel, P. (1997).Effect of environmental factors on mustard aphid infestation in different germplasm of Indian mustard.*Coss. Oilseeds Res.***14**(2): 278-288.

Saran, G. and Giir, G. (1987). Influence of dates of sowing on mustard spacies under semiarid rainfed conditions of North-West India. *J. Agric. Sci. Camb.***97**: 189-195.

Schmuttere, H. (1978). Pest in tropical crops.*In:*Kranz, J., H. Schmuttere and W. Koch (eds.). Diseases, Pests and Weeds in Tropical Crops.John Wiley and sons, Chichester New York, Toronto. pp. 237-241.

Scott, R.K., Qgunremi, E.A., Ivind, J.D. and Mendham, N.J. (1973).The effect of sowing date and season on growth and yield of oilseed rape.*J. Agric. Sci. Camb.***81**: 277-285.

Sekhon, B.S. and Ahman, I. (1992).Insect resistance with species reference to mustard aphid.*In:*Labana, K.S. and Banga, S.K. (eds.) pp. 206-221.

Shahidulla, M., islam, U. and Hussain, M. (1997). Effect of sowing dates andf varieties on yield and yield attributes of mustard. *Bangladesh J. Sci. Ind. Res.***32**(4): 515-516.

Shahjahan, M. (1994).Field and laboratory evaluation of some mustard germplasms for resistance to aphid. M.S. Thesis. Dept. of Entomology, BAU, Mymensigh.Pp. 89.

Shivani, K., Sanjeev, P. and Kumar, S. (2002). Response of Indian mustard to sowing date and row spacing in mid-hills of Sikkin under rainfed conditions.Indian J. Agrin. 47(3): 405-410.

Sihag, J.S., Manohar, S.S. and Chaudhary, T. (2003).Combined effect of sulphur and time of sowing on yield and quality of mustard. *J. Eco. Physiol.***6**(2): 65-68.

Singh, D., Kumar, V. and Kumar, D. (2000). Genetics of percent plant infestation due to mustard aphid at different growth stages, siliqua characters and seed yield in Indian mustard. *Ann. Biol.***16**(2): 185-190.

Singh, R.N., Das, R. and Singh, R.K. (1982).Differential response of mustard varieties to aphid.*Indian J. Ent.* **44**(4): 408-410.

Singh, S.S. and Lal, M.N. (1999).Seasonal incidence of mustard aphid on mustard crops.*J. Ent. Res.***23**(2): 165-167.

Singh, S. R., A. Narain, K. P. Srivastava and J. A. Siddiqui. 1965. Fecundity of Mustard Aphid of Different Rapes and Mustard Species. Indian Oilseeds J. 9(3): 215-219.

Sinha, R.P., Yazdani, S.S. and Verma, G.D. (1989).Population dynamics of mustard aphid in relation to ecological parameters.*Indian J. Ent.***52**(3): 387-392.

Srivastava, A., Singh, H. and Thekur, H.L. (1996).Assessment of avoidable yield loss caused by green peach aphid and mustard aphid in mustard.*Indian J. Plant Protec.***24** (1 & 2): 115-116.

Srivastava, A.S., Negam, P.M. and Awasthi, B.K. (1972).Survey of pests on mustard crops.*J. Sci. Tech.***10**: 165-166.

Shrivastava, Ajay (1999): Effect of date of sowing and varieties on the incidence of mustardaphid,Lipaphiserysimi (Kalt.) on rapeseed-mustard.–Journal ofOilseeds Research, 16(2): 380-381

Stryer, L. (1980). Fatty acid metabolism in Biochemistry. New York, San Franisco. p. 385.

Takar, B.L., Deshwal, H. and Jat, B.L. (2003).Screening of different varieties of mustard and mustard aphid infestation.*Ann. Biol.***19**(2): 209-212.

Tapas, Bapari, Bhattacharya Swarnali and DharTapamay (2007).Effect of abiotic factors and time of sowing on incidenceof mustard aphid, *Lipaphiserysimi*(Kalt.) (Aphididae :Hemiptera) in Terai Region of West Bengal. *Environ. And Eco*.,25(Special 4): 1129-1133

Tripathi, N.L.M., Sachan, G.C., Verma, S.K. and Pathak, P.K. (1986).Developmental behavior of mustard aphid on different part of mustard.*Indian J. Entomol.***48**(3): 295-300.

Uttam, S.K., Mohan, K. and tripathi, R.A. (1993).Studies on population dynamics of mustard aphid.*Ann. Pl. Prot. Sci.***1**(1): 34-37.

Vekaria, M.V. and patel, G.M. (1998).Studies on number on ganrations of mustard aphid under laboratory conditions.*Pest Manage. Econ. Zool.***6**(2): 163-165.

Vekaria, M.V. and Patel, G.M. (2003).Screening of promising mustard genotypes for resistance against mustard aphid.*Indian J. Entomol.***62**(1): 37-42.

Vekaria, M.V. and Patel. G.M. (2000): Effect of sowing dates on the incidence of mustard aphid and its natural enemies in north Gujrat. – Journal of Oilseeds Research, 17(2): 335-340.

Verma, R.K., Neeraja, A. and Rajak, S.K. (2005).Screening of mustard genotypes against mustard aphid.*J. Oilseeds Res.***22**(1): 202-222.

Wahhab, M.A., Mondal, M.R.I., Akbar, M.A., Alam, M.S., Ahmed, M.U. and Begum, F. (2012). Status of oil crops production in Bangladesh. Oilseed Res. Centre, Bangladesh Agril. Res. Inst., Joydebpur, Gazipur. pp. 4-62.

CHAPTER VII

APPENDICES

Appendix I. Characteristics of the Experimental field of Sher-e-Bangla Agricultural University, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomic Farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Fallow- Mustard

B. Physical and chemical properties of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
pH	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20.00
Exchangeable K (mel 1 00 g soil)	0.10
Available S (ppm)	45

Source : SRDI, 2013

Appendix II. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from November, 2013 to February, 2014

Month	Average air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)	Total Sunshine per day (hrs)
	Maximum	Minimum	Mean			
November, 2013	29.7	20.1	24.9	65	5	6.4
December, 2013	26.9	15.8	21.35	68	0	7.0
January, 2014	24.6	12.5	18.7	66	0	5.5
February, 2014	33.7	23.8	28.81	69	0	5.8

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan. Dhaka