VARIATIONS IN THE INCIDENCE OF MUSTARD APHID ON DIFFERENT VARIETIES OF MUSTARD

MIR HASAN-AL-BANNA

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

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BY

MIR HASAN-AL-BANNA
Registration No. 10-04006

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Approved by

Supervisor	**Co-Supervisor**
Dr. Mst. Nur Mohal Akhter Banu	**Dr. Md. Abdul Latif**
Associate Professor	**Professor**
Department of Entomology	**Department of Entomology**

Dr. Mst. Nur Mohal Akhter Banu
Chairman
Department of Entomology

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

CERTIFICATE

This is to certify that thesis entitled, *"VARIATIONS IN THE INCIDENCE OF MUSTARD APHID ON DIFFERENT VARIETIES OF MUSTARD"* submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE in ENTOMOLOGY*, embodies the result of a piece of bona fide research work carried out by *MIR HASAN-AL-BANNA,* **Reg. No.** ***10-04006*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: JUNE, 2016

Dr. Mst. Nur Mohal Akhter Banu
Associate Professor
Department of Entomology
Research Supervisor

DEDICATED TO MY BELOVED FATHER

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ABSTRACT

The experiment was conducted in the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November 2015 to March 2016 to observe the incidence of mustard aphid on different variety of mustard. The experiment was laid out in randomized complete block design with three replications. Eight mustard varieties such as T_1 (BARI Sharisha-9), T_2 (BARI Sharisha-10), T_3 (BARI Sharisha-11), T_4 (BARI Sharisha-13), T_5 (BARI Sharisha-14), T_6 (BARI Sharisha-15), T_7 (BARI Sharisha-16) and T_8 (BARI Sharisha-17) were evaluated against aphid infestation on plants, leaves, inflorescence and pods to find out the tolerant variety(ies) against aphid. Out of eight mustard varieties, T_5 (BARI Sharisha-14) was found as the most preferred host for aphid infestation. where as BARI Sharisha-13 performed as least preferred variety in terms of aphid infestation on plants, leaves, inflorescence, and pod. The most aphid susceptible variety BARI Sharisha-14 produced the lowest seed yield per plot and BARI Sharisha-13 produced highest seed yield with least aphid infestation. The study revealed that the BARI Sharisha-13 manifested the lowest aphid infestation and produced highest yield. Conversely, BARI Sharisha-14 manifested the highest aphid infestation and produced lowest seed yield.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I
INTRODUCTION

Mustard (*Brassica campestris* L.) and rapeseed (*Brassica olitorius* L.) belongs to the genus *Brassica* of the family Cruciferae and are one of the leading oilseed crops in Bangladesh as well as in the World. In Bangladesh more than 221.47 thousand metric tons of rape seed and mustard produced from total 289.55 thousand hectares of cultivable land in the year 2014-2015 (BBS, 2015). Mustard occupied the top of the list in respect of area and production compared to other oilseed crops that are grown in Bangladesh. It is mainly a self-pollinating crop, although on an average 7.5 to 30% out-crossing does occur under natural field conditions (Abraham 1994; Rakow and Woods 1987). Oilseed crops play a vital role in human nutrition. It is used as a condiment, salad, green manure and fodder crop, and as a leaf and stem vegetable in the various mustard growing countries of the World. In Bangladesh, sources of edible oils are rapeseed-mustard, sesame, groundnut, soybean, niger, linseed, sunflower and safflower. But rapeseed, mustard are the important oilseed crops of the world after soybean and palm (FAO 2004).The Oliferous oil is not only the rich source of energy (about 9 Kcal/g) but also the source of rich fat soluble vitamins A, D, E and K. The National Nutrition Council (NNC) of Bangladesh Recommended Dietary Allowance (RDA) per capita per day as 6g of oil for a diet with 2700 Kcal. On RDA basis, the edible oil need for 150 millions people is 0.39 million tons equivalent to 0.82 million tons of oilseed (NNC 1984). Rapeseed oil is widely used as cooking oil and medicinal ingredient and supplies fat in our daily diet. Domestic production of edible oil almost entirely comes from rapeseed and mustard cultivation occupying only about 2% area of total cultivation area in Bangladesh (BBS,

2015). The annual oil seed production of 0.41 million tons of which the share of rapeseed-mustard was .21 million tons, which comes about 52% of the total edible oil seed production (BBS, 2015). Bangladesh is running with acute shortage of edible oil and it is about 70% of the total demand of the country. Annually producing about 0.16 million tons of edible oil as against the requirement of 0.5 million tons and to meet up the demand, the country has to import oil and oilseeds to the tune of about 160 million US $ every year (Wahhab *et al*. 2002). Oil cake of mustard is used as fertilizer in the South Asian region for centuries. In combination with cow dung manure and ashes, the oil cakes sustained the fertility levels of marginal farms. Oil cakes render indirect help in promoting the micro flora and micro fauna of soils providing readily available amino acids and free sugars to the latter. It is clear that oil cakes are rich sources of nitrogen, phosphorus and potassium macronutrients and trace amounts of other micro nutrients.

There are many insect pests of mustard crop like mustard aphid (*Lipaphis erysimi* Kalt.), sawfly (*Athalia lugens* Kiug), etc. Mustard aphid is the most serious and destructive pest and limiting factors for successful cultivation of mustard in South Asia (Bakhetia 1983 and Zaman 1990). The rate of reproduction varies from 5-9 young in a single day by a single female and the total number of young produced by the female varies from 76-188 (Nair 1986). Both the nymph and adult of the aphid suck sap from leaves, stems, inflorescences and pods, as a result the plant show stunted growth, flowers wither and pod formation is hindered (Atwal and Dhaliwal 1997; Begum 1995 and Butane and Jotwanil 1984).

Farmers usually spray chemical pesticides many times during the crop season to control insect pests. This leads to environmental pollution with a consequent of increased health hazard to the growers and consumers. Moreover, it also leads to the development of resistance to target pests (David and Kumaraswami 1989) with also a negative effect on natural enemies (Tewari and Moorthy 1985) and other beneficial and causes disruption of biodiversity. Greater concern of the environment and growing awareness of the importance of the complex interrelationship of the organism within the ecosystem have lead to the realization that few pest could be eradicated totally without interfering natural control. The growing awareness of the shortcoming of the chemical insecticides has necessitated for the exploration for alternative methods of pest control, which is relatively free from adverse side effects. Among the various alternatives, the exploitation of host plant resistance is perhaps the most effective, convenient, economical and environmentally acceptable method of insect pest control (Dhaliwal and Dilawary 1993). At present, effective control techniques other than insecticide application against insect pests of agricultural crops are highly demanding.In view of this requirement an experiment was conducted to find the susceptible mustard varieties against aphid with following objectives

i. To identify the susceptible varieties of mustard against mustard aphid and
ii. To observe the infestation of aphid on different varieties of mustard.

CHAPTER II
REVIEW OF LITERATURE

Mustard is one of the important oil crop in Bangladesh and as well as many countries of the world. There are many insects pests of mustard among them aphids, mustard sawfly and mustard leaf eating caterpillar are the most important. Farmers mainly control the insect pest using different chemicals. The concept of management of pest employing environmental factors and eco-friendly materials gained momentum as mankind want more safer environment. But the research work in these aspects so far done in Bangladesh and elsewhere is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the control of insect pest through managing environmental factors and using chemicals and botanicals so far been done at home and abroad have been reviewed in this chapter.

2.1. Taxonomic position of mustard aphid

Taxonomic position of the mustard aphid, *Lipaphis erysimi* (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*

2.2. Geographical distribution of aphid

The mustard aphid, *Lipaphis erysimi* (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).

2.3. Biology and life history of aphid

Eastop (1961) and Martin (1983) described the taxonomic features of apterae and alate of *Lipaphis erysimi* (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, *Lipaphis erysimi* (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), *Raphanus sativus* (radish) and *Solanum melongena* (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 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 mm3 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 for malate 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 December. Their study reflected to the host plant availability. They also observed a significant positive relationship between body weights with the number of weel-developed embryos. 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 mm3) than alate (0.063 mm3). 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 *Lipaphis erysimi* (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 *Lipaphis erysimi* (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 *Lipaphis erysimi* starts when average temperature varied from 7.5 to 15oC with RH 62.5-93.5%.

2.4. Seasonal Abundance of aphid

Abiotic factors seem to influence the aphid infestation due to large variation in the date of aphid infestation and its progress. Under favorable weather conditions, mustard aphids spread very rapidly forcing the farmers to repeatedly use insecticides. However, need based application of the insecticides is desirable in order to avoid pollution related hazards. Several studies have been done to develop correlation between weather parameters and aphid population. They reported that the peak period of aphid activities on B. juncea varied from end of January to first week of March. Based on simple linear regression analysis between aphid population and the corresponding weather for 3 years, Bishnoi et al. (1992) reported that the either mean temperature or saturation deficit contributes significantly to the buildup aphid population.

Samdur et al. (1997) from Delhi observed that average maximum and minimum relative humidity had positive relationship with mean aphid infestation index. A minimum relative humidity of 30 to 35% and average maximum relative humidity of 85 to 88% were found to be the most congenial conditions for increase in aphid population. Kulat et al. (1997) found that in Nagpur, a combination of ambient maximum temperature (26.4 to 29.00C), minimum temperature (8.4 to 12.60 C) and high relative humidity ranging from 75 to 85 percent in the month of January favoured aphid multiplication, whereas the activity of the aphid ceased at relative humidity of 65 per cent and below. A lot of information is available about the relationship between various biotic and abiotic factors and incidence, multiplication and disappearance of mustard aphid. Based on the

understanding of the relationship between these factors and levels of aphid infestation, the correlation studies help in developing the regression models for forecasting the aphid infestation under existing condition. Prasad and Phadke (1987) from their field studies at IARI, New Delhi, worked out semi logeX equation to be best fit for almost all the stages of the crop growth relating the yield with aphid population. Mishra and Singh (1986) observed similar type of relationships between the yield of mustard and aphid infestation levels. Based on field observation, Prasad et al. (1984) from IARI, New Delhi reported that maximum, minimum and mean temperatures existing one or two preceding weeks showed a significant and negative correlation with the prevailing population with a lower value of determination factor. From field studies conducted at IARI, New Delhi, (Subhash Chander 1995; Samdur et al., 1997) reported that the mean aphid infestation index was negatively correlated with maximum temperature, evaporation, sunshine and wind velocity and it was positively correlated with maximum relative humidity and minimum relative humidity in a significant way in case of timely sown crop. Prasad (2003) at IARI, New Delhi, developed a typical model equation for forecasting the aphid population in Brassica crop, based on aphid population recorded at weekly intervals and the corresponding weather parameters viz. maximum, minimum and mean temperature, relative humidity, saturation deficit and the total rainfall. They also incorporated the aphid population at one week, two weeks and three weeks before the observation date. Development stage of the aphids can be effectively expressed as a temperature sum or degree-day (Chakravarty and Gautam 2002). Many workers worked out the relationship between growing degree-days and aphid growth and development and population build-up in Brassica crop and this relationship can be used for a computer forecast system to

predict aphid population. Prasad and Phadke (1987) at IARI, New Delhi, worked out the thermal requirement for identifying the peak aphid population in Indian mustard. They observed that about 407.3 0 D was required for attaining peak aphid population, considering 5o C as base temperature. However, a quantitative, effective assessment / forecast models relating the aphid population with the biotic and abiotic factors is lacking, especially under severe winter conditions. Under such conditions it was found that some factors were positively correlated whereas, in some other cases it was negatively correlated. Most often aphid population depends on the growth of the crops and it was found that growths of the crop are linearly related with growing degree days. Therefore, the present study was taken up to fill in the gaps in the research and come out with a satisfactory model to assess or forewarn the aphid population in relation to various phonological conditions in the mustard crop which would go a long way in reducing the yield losses due to this dreaded pest.

2.5. Damage caused by aphid

Rohilla et al. (1987) conducted a four year investigation with six *Brassica* for their resistance to *Lipasphis erysimi* (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 % yield 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 another 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 *Myzus persicae* 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.

2.6. Susceptibility of different 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 F1 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, *Lipaphis erysimi* (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, *Lipaphis erysimi* (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 *Lipaphis erysimi* and gave the highest yields.

Kher and Rataul (1992) 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 *Lipaphis erysimi*. Kher and Rataul (1992b) screened that nineteen strains of rape were tested in the field in Punjab, India, in 1987-1989 for resistance to *Lipaphis erysimi*. 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, *Lipapgis erysimi* (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*], *Diplo taxissiifolia, B. tournefortii, B. campestris* and lines/cultivars of *B. juncea* (10), *B. napus* (10) and *B. carinata* (10) for resistant to mustard aphid (*Lipaphis erysimi*). 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, *Diplo taxissiifolia* 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, *Lipapgis erysimi*, 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 Indian 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 *Lipaphis erysimi*cvs. GSL-1510 and ISN-706 had the lowest aphid infestation.

Singh *et al.* (2000) reported that the nine parents and their 36 F1 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, *Lipaphis erysimi* (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 yield less (46.12 %) due to infestation by *Myzu spersicae* and *L. erysimi*, followed 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.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from November 2015 to March 2016 to study the incidence of mustard aphid in on different varieties of mustard. The details of the materials and methods that used to conduct the experiment are presented below:

3.1 Location

The experiment was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is 23074/N latitude and 90035/E longitude and an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Climate

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Details of the meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka and presented in Appendix I.

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka and presented in Appendix II.

3.4 Variety used in the experiment

Eight varieties of mustard were used in the experiment. Mustard seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Treatment & design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing all of the

treatments. Each experiment consists of total 24 plots of size 2.0 m × 1.0 m. The layout of the experiment is shown in Figure 1

Table no 1. Different mustard varieties

Treatment	Variety	Place of collection
T_1	BARI Mustard-09	BARI
T_2	BARI Mustard-10	BARI
T_3	BARI Mustard-11	BARI
T_4	BARI Mustard-13	BARI
T_5	BARI Mustard-14	BARI
T_6	BARI Mustard-15	BARI
T_7	BARI Mustard-16	BARI
T_8	BARI Mustard-17	BARI

BARI : Bangladesh Agricultural Research Institute

3.6 Land preparation

The experimental plot was opened in the first week of November 2012 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for sowing of mustard Seeds.

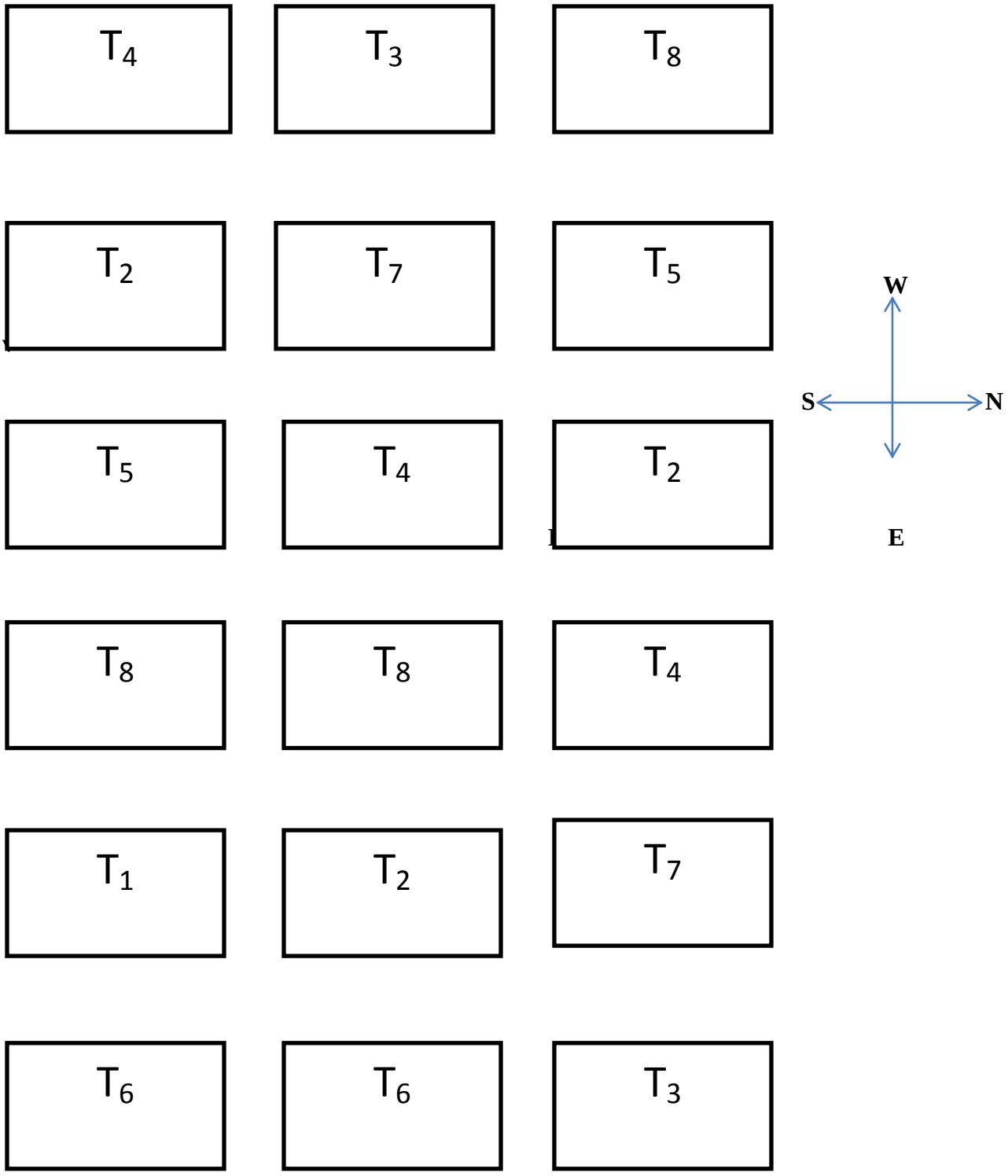

Figure 1. The layout of the experiment

Plot size: 2.0 m × 1.0 m

Plot to pot distance: 50 cm

Between replication: 1.0 m

3.7 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of Urea, TSP, MoP, Gypsum, Zinc sulphate and borax, respectively were applied. The entire amount of TSP, MoP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Urea was applied in two equal installments at final land preparation and at 30 days of seed sowing. The dose and method of application of fertilizers are shown in Table 1 (Anon., 2005).

Table 2. Dose and method of application of fertilizers in mustard field

Fertilizers	Dose (kg/ha)	Application (%)	
		Basal	Top dressing
Urea	300	50	50
TSP	180	100	
MP	100	100	
Gypsum	180	100	
Zinc Sulphet	07	100	
Borax	15	100	--

3.8 Intercultural operations

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

3.8.1 Irrigation and drainage

Single irrigation was provided before flowering stage and it was arranged well drained facilities as prevention process of removing rain water if any.

3.8.2 Weeding

Weeding was done in the field to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at flowering stage by mechanical means.

3.9 Data collection

The data on the following parameters were recorded at different time intervals as given below:

- Total number of infested plants/plot.
- Total number of branch/plant
- Total number of infested branch/plant
- Total number of Aphid (Per/cm)
- Total number of pods/ plants
- Total number of infested pods/ plants
- Total number of seeds/pod
- Weight of seed/plant
- Weight of pods/ plants.

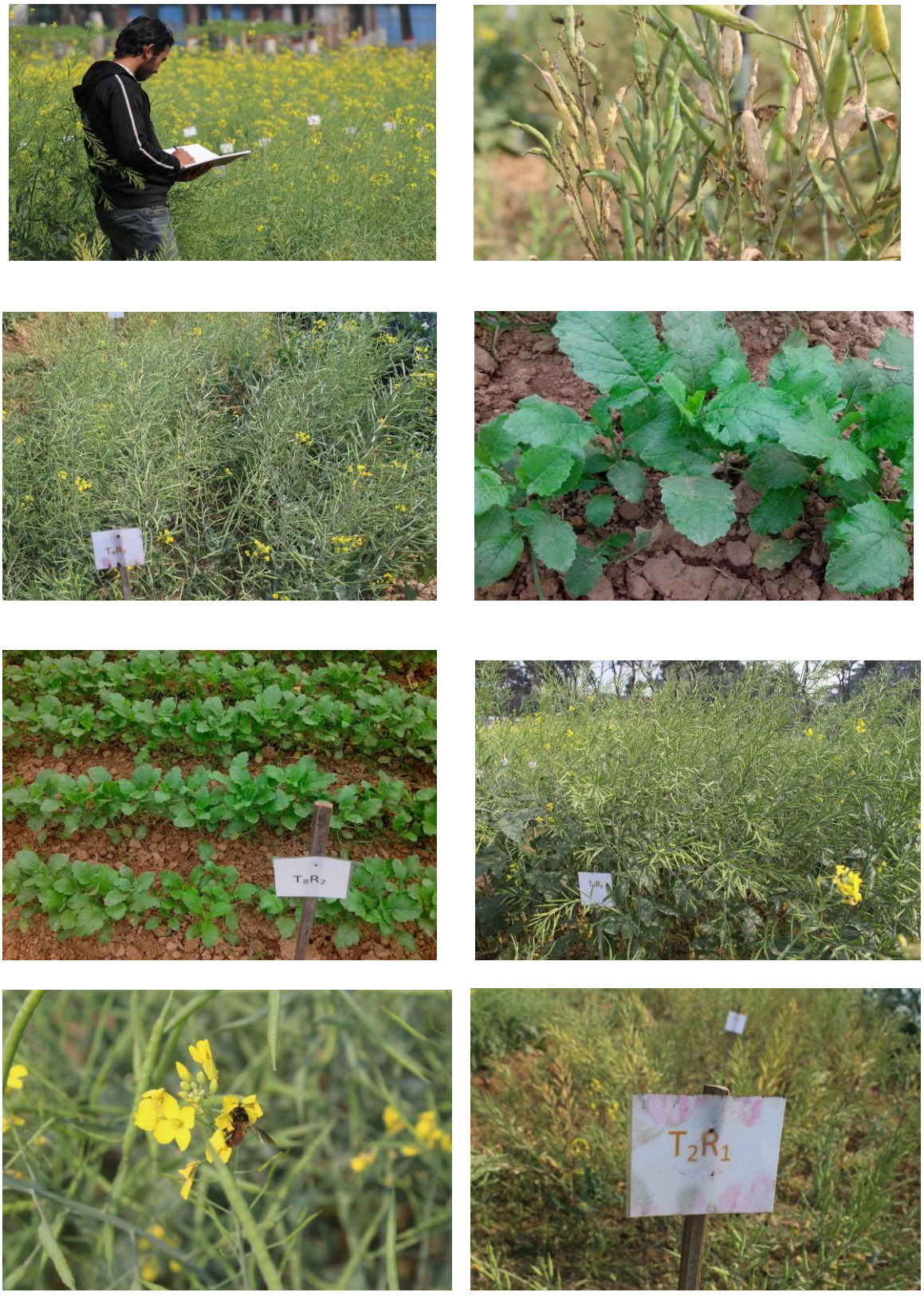

Figure 2. Experimental plot at the research field of SAU

3.10. Procedure of recording data

3.10.1 Total number of infested plants/plot.

Total number of infested plant was counted from each replication from randomly selected five plants.

3.10.2 Total number of branch

Total number of branch was counted from each replication from randomly selected five plants also.

3.10.3 Total number of infested branch

Total number of infested branch was counted from total number of branch among selected five plants.

3.10.4 Total number of pod

Total number of pod was counted from each replication from randomly selected five plants. Then average number of pod/plant was counted. Average number of seed per plant was also counted and total seed weight was measured.

3.10.5 Total number of infested pod

Total number of infested pod was counted from total number of pod among selected five plants.

3.10.6 Total number of Aphid

Total number of aphid was counted between 1cm from the inflorescence plant from each replication from randomly selected five plants.

3.11 Harvesting, threshing and cleaning

The mustard was harvested at maturity of plant and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken at harvesting, threshing and also cleaning mustard. The seeds were cleaned and finally the weight was calculated and converted into per hectare yield.

3.12 Statistical analysis

Data were analyzed by MSTAT-C software for proper interpretation. The data recorded on different parameters were subjected to analysis of variance (ANOVA) and means were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance.

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 2015 -2016 to evaluate eight mustard varieties against aphid and the varieties are - BARI Sharisha-9, BARI Sharisha-10, BARI Sharisha-11, BARI Sharisha-13, BARI Sharisha-14, BARI Sharisha-15, BARI Sharisha-16, BARI Sharisha-17 cultivated in 13 November to find out the susceptible variety(ies) against mustard aphid. The findings of the study have been presented and discussed under the following sub-headings:

4.1. Effect of mustard varieties on plant infestation

Significant variations were observed among eight mustard varieties on plant infestation by aphids at different days after sowing (Table 3). In case of 58 DAS, the highest plant infestation (45.83%) by aphids was recorded in mustard variety BARI Sharisha-17 , which was statistically different from all other varieties which was followed by plant in T_2 (43.33%), T_5 (30.00%) and T_6 (25.00%). Conversely, the lowest plant infestation (17.50%) was recorded in T_4 (BARI Sharisha-13), which was followed by T_1 (18.33%), T_7 (23.33%) and T_3 (25.00%). More or less similar trends of results were observed at both 65 DAS,72 DAS and 79 DAS. In case of 65 DAS, the highest infestation (46.50%) by aphids was recorded in T_8, which was statistically different from all other mustard varieties. This was followed by (42.50%) plant infestation in T_2 followed by T_5(28.33%) and T_6 (28.33%). Contrastingly, the lowest pod infestation (20.00%) was recorded in T_4 (BARI Sharisha-13), which was followed by T_6 (25.83%), T_1 (25.83%) and T_3(27.50%).

Similes in case of 72 DAS, the highest plant infestation (53.67%) by aphids was recorded in T_8 (BARI Sharisha-17), which was statistically different from all other mustard varieties. This was followed by T_2 (45.83%), T_6 (34.17%) and T_5(32.50%).The lowest plant infestation (25.83%) was recorded in T_4 (BARI Sharisha-13), which was followed by T_1 (30.00%), T_3 (31.67%) and T_7 (32.00%). In case of 79 DAS, the highest plant infestation (73.33%) by aphids was recorded in mustard variety BARI Sharisha-17 , which was statistically different from all other varieties which was followed by plant in T_6 (56.67%), T_7 (55.00%) and T_2 (50.83%).The lowest plant infestation (30.00%) was recorded in T_4 (BARI Sharisha-13), which was followed by T_1 (41.67%), T_5 (45.83%) and T_3 (48.33%).

4.2. Effect of mustard varieties on plant branch infestation by aphids

Significant variations were observed among eight mustard varieties on plant leaf infestation by aphids at different days after sowing (Table 4). In case of 51 DAS, the highest plant branch infestation (22.74%) by aphids was recorded in mustard variety BARI Sharisha-15 , which was statistically similar with remaining others and different from all other varieties which was followed by plant in T_8 (19.44%), T_5 (12.38%) and T_3 (10.97%). Conversely, the lowest plant branch infestation (7.78%) was recorded in T_4 (BARI Sharisha-13), which was followed by T_7 (10.00%), T_2 (10.42%) and T_1 (10.52%). More or less similar trends of results were observed at both 58 DAS,72 DAS and 79 DAS. In case of 58 DAS, the highest infestation (22.73%) by aphids was recorded in T_8, which was statistically different from all other mustard varieties. This was followed by (16.15%) branch infestation in T_5 followed by T_2(15.90%) and T_3 (12.40%). Contrastingly, the lowest branch infestation (7.25%) was recorded in T_4 (BARI

Table 3. Effect of different mustard varieties on plant infestation by aphid

Treatments	Infested plant/plot(%) At different day after sowing				
	51DAS	58DAS	65DAS	72DAS	79DAS
T_1	17.50	18.33c	25.83bc	30.00bc	41.67cd
T_2	40.83	43.33ab	42.50ab	45.83ab	50.83bc
T_3	19.17	25.00bc	27.50abc	31.67bc	48.33bc
T_4	16.67	17.50c	20.00c	25.83c	30.00d
T_5	25.83	30.00abc	28.33abc	32.50bc	45.83bc
T_6	23.33	25.00bc	28.33abc	34.17bc	56.67b
T_7	22.83	23.33bc	25.83bc	32.00bc	55.00b
T_8	41.67	45.83a	46.50a	53.67a	73.33a
CV (%)	23.53	13.71	18.75	15.28	13.51
LSD	11.43	9.73	8.90	9.13	6.86
Level of significance	NS	*	*	*	**

In a column means with similar letter(s) are not significantly different

T_1: BARI Mustard- 09

T_2: BARI Mustard- 10

T_3: BARI Mustard- 11

T_4: BARI Mustard- 13

T_5: BARI Mustard-14

T_6: BARI Mustard-15

T_7: BARI Mustard-16

T_8: BARI Mustard-17

Sharisha-13), which was followed by T_6 (8.51%), T_1 (9.74%) and T_7(10.00%).in case of 72 DAS, the highest branch infestation (32.08%) by aphids was recorded in T_7 (BARI Sharisha-16), which was statistically different from all other mustard varieties. This was followed by T_6 (24.70%), T_3 (24.21%) and T_5(22.06%).On the other hand, the lowest plant branch infestation (12.73%) was recorded in T_4 (BARI Sharisha-13).At 79 DAS, the highest plant branch infestation (35.42%) by aphids was recorded in mustard variety BARI Sharisha-16 , which was statistically different from all other varieties which was followed by plant in T_5 (33.73%), T_6 (29.22%) and T_8 (26.93%). Conversely, the lowest plant branch infestation (16.27%) was recorded in T_4 (BARI Sharisha-13

4.3. Effect of mustard varieties on leaf infestation by aphid

Significant variations were observed among eight mustard varieties on plant leaf infestation by aphids at different days after sowing (Table 5).No significant difference was observed on different varieties regarding leaf infestation at 51 DAS and 65 DAS. At 58 DAS, the highest plant leaf infestation (16.52%) by aphids was recorded in mustard variety BARI Sharisha-17 , which was statistically similar to from all other varieties which was followed by plant in T_2 (10.53%). Conversely, the lowest plant leaf infestation (7.37%) was recorded in T_4 (BARI Sharisha-13), which was followed by T_1 (7.58%), T_5 (8.38%) and T_3 (8.57%).but at 72 DAS highest leaf infestation was observed in T_6(24.24% and lowest leaf infestation was observed in T_4(13.35%).Similar trends of results were observed 79 DAS.

Table 4. Effect of different mustard varieties on branch infestation by aphid

Treatment	Infested Branch/plant(%) At different day after sowing				
	51DAS	58DAS	65DAS	72DAS	79DAS
T_1	10.53bc	9.74ab	11.64	16.11ab	18.17e
T_2	10.42bc	15.90ab	13.49	13.26ab	19.51de
T_3	10.97bc	12.40ab	11.67	24.21ab	25.91cd
T_4	7.78c	7.25b	10.35	12.73b	16.27e
T_5	12.38bc	16.15ab	14.08	22.06ab	33.73ab
T_6	22.74a	8.51b	10.68	24.70ab	29.22abc
T_7	10.00bc	10.00ab	16.04	32.08a	35.42a
T_8	19.44ab	22.73a	21.30	15.01ab	26.93bc
CV (%)	13.67	12.91	23.38	8.37	16.34
LSD	1.80	1.68	5.99	1.69	4.24
Level of sig.	**	**	NS	**	**

In a column means with similar letter(s) are not significantly different

T_1: BARI Mustard- 09

T_2: BARI Mustard- 10

T_3: BARI Mustard- 11

T_4: BARI Mustard- 13

T_5: BARI Mustard-14

T_6: BARI Mustard-15

T_7: BARI Mustard-16

T_8: BARI Mustard-17

Table 5. Effect of different mustard variety on plant leaf infestation by aphid

Treatment	Infested leaf/plant (%) At different day after sowing				
	51DAS	58DAS	65DAS	72DAS	79DAS
T_1	6.51	7.58b	6.85	13.77b	30.37cd
T_2	7.72	10.53ab	16.22	19.17ab	26.19d
T_3	5.23	8.57b	10.00	22.77a	36.57bc
T_4	6.41	7.37b	7.65	13.35b	23.14d
T_5	6.48	8.38b	8.74	18.84ab	43.89ab
T_6	6.90	9.08b	10.48	24.24a	46.43a
T_7	6.97	9.42b	12.35	20.69ab	39.52ab
T_8	8.26	16.52a	10.95	17.76ab	38.61ab
CV (%)	22.81	10.12	31.25	21.10	12.98
LSD	2.26	0.98	6.44	3.99	4.67
Level of sig.	NS	**	NS	*	**

In a column means with similar letter(s) are not significantly different

T_1: BARI Mustard- 09

T_2: BARI Mustard- 10

T_3: BARI Mustard- 11

T_4: BARI Mustard- 13

T_5: BARI Mustard-14

T_6: BARI Mustard-15

T_7: BARI Mustard-16

T_8: BARI Mustard-17

From this above findings it was revealed that the mustard variety of BARI sharisha-13 manifested the lowest plant leaf infestation by aphids followed by BARI sharisha-11.

4.4. Effect of variety on the inflorescence infestation by aphid

Significant variations were observed among eight mustard varieties on aphid population at different days after sowing (Table 6). In case of 65 DAS, the highest aphid population (176.67) by aphids was recorded in mustard variety T_1(BARI Sharisha-9), which was statistically different from all other varieties and followed by plant in T_7 (149.00), T_8 (130.00) and T_3 (112.00). Conversely, the lowest aphid population (72.33) was recorded in T_4 (BARI Sharisha-13).Similar trends of results were observed at both 72 DAS and 79 DAS. In case of 72 DAS, the highest aphid population (179.33) by aphids was recorded in T_1, which was statistically different from all other mustard varieties. This was followed by (155.00) aphid population in T_7 followed by T_8(135.00) and T_3 (122.33). Contrastingly, the lowest aphid population (84.67) was recorded in T_4 (BARI Sharisha-13).in case of 79 DAS, the highest aphid population (183.67) by aphids was recorded in T_1 (BARI Sharisha-9), which was statistically different from all

other mustard varieties. This was followed by T_7 (159.33), T_8 (139.67) and T_3(131.67). On the other hand, the lowest aphid population (90.33) was recorded in T_4 (BARI Sharisha-13).

4.5. Effect of mustard varieties on pod infestation by aphids

Significant variations were observed among eight mustard varieties on pod infestation by aphids at different days after sowing (Table 7). In case of 51 DAS, the highest pod infestation (78.85%) by aphids was recorded in mustard variety BARI Sharisha-9,

Table 6. Effect of different mustard varieties on the inflorescence infestation by aphid

Treatments	**Aphid population/10cm inflorescence**		
	65DAS	72DAS	79DAS
T_1	176.67a	179.33a	183.67a
T_2	102.00e	110.00e	120.00e
T_3	112.00d	122.33d	131.67d
T_4	72.33h	84.67g	90.33g
T_5	84.00g	99.33f	106.33f
T_6	89.67f	111.67e	114.33e
T_7	149.00b	155.00b	159.33b
T_8	130.00c	135.00c	139.67c
CV (%)	2.78	2.70	3.59
LSD	3.22	3.41	4.75
Level of sig.	**	**	**

In a column means with similar letter(s) are not significantly different

T_1: BARI Mustard- 09 T_5: BARI Mustard-14

T_2: BARI Mustard- 10 T_6: BARI Mustard-15

T_3: BARI Mustard- 11 T_7: BARI Mustard-16

T_4: BARI Mustard- 13 T_8: BARI Mustard-17

which was statistically similar T_7 (78.73%), T_3 (76.91%) and T_2 (75.67%).The lowest pod infestation (46.56%) was recorded in T_4 (BARI Sharisha-13).Similar trends of results were observed at both 58 DAS and 65 DAS. In case of 58 DAS, the highest infestation (83.74%) by aphids was recorded in T_1(83.74), which was statistically similar with all other mustard varieties expect T_4(45.82).In case of 65 DAS, the highest pod infestation (86.93%) by aphids was recorded in T_1 (BARI Sharisha-9), which was statistically different from all other mustard varieties. This was followed by T_3 (80.16%), T_2 (77.29%) and T_7(75.96%). On the other hand, the lowest pod infestation (45.76%) was recorded in T_4 (BARI Sharisha-13).

4.6. Effect of mustard variety on seeds production infested by aphid

Statistically significant differences were found for number of seeds/pod of mustard due to different varieties infested by aphid (Table 8).The highest seeds/pod (24.00) was recorded from T_4 (BARI sharisha-13) which was statistically different than others. Second highest seeds/pod was observed in T_1 (18.67%) which was statistically similar with T_2 (18.00). On the other hand, the lowest seeds/pod (10.00) was recorded from T_5 (BARI sharisha-14).

4.7. Effect of varieties on grain yield of mustard infested by aphid

Significant variations were observed among eight of mustard varieties on yield per plot . The highest yield (678 g/plot) was recorded on T_4 (BARI sharisha-13), which was statistically different from all other mustard varieties. On the other hand, the lowest yield (405g) was recorded in T_5 and T_8 (435 g),

Table 7. Effect of different mustard varieties on pod infestation by aphid

Treatments	**% Infested pod/plant**		
	51DAS	58DAS	65DAS
T_1	78.85a	83.74a	86.93a
T_2	75.67a	75.06ab	77.29ab
T_3	76.91a	77.96a	80.16a
T_4	46.56b	45.82c	45.76d
T_5	58.02ab	56.98bc	46.62d
T_6	68.98ab	72.29ab	61.33c
T_7	78.73a	75.02ab	75.95ab
T_8	66.44ab	64.91ab	68.66bc
CV (%)	15.73	13.60	8.50
LSD	10.94	9.49	5.83
Level of sig.	*	**	**

In a column means with similar letter(s) are not significantly different

T_1: BARI Mustard- 09

T_2: BARI Mustard- 10

T_3: BARI Mustard- 11

T_4: BARI Mustard- 13

T_5: BARI Mustard-14

T_6: BARI Mustard-15

T_7: BARI Mustard-16

T_8: BARI Mustard-17

Table 8. Number of seeds/pod on different mustard varieties after infestation by aphid

Treatments	Seed/pod (Number)
T_1	18.67b
T_2	18.00b
T_3	13.33c
T_4	24.00a
T_5	10.00d
T_6	14.00c
T_7	13.00c
T_8	12.67c
CV (%)	9.61
LSD	1.50
Level of sig.	**

In a column means with similar letter(s) are not significantly different

T_1: BARI Mustard- 09

T_2: BARI Mustard- 10

T_3: BARI Mustard- 11

T_4: BARI Mustard- 13

T_5: BARI Mustard-14

T_6: BARI Mustard-15

T_7: BARI Mustard-16

T_8: BARI Mustard-17

Table 9. Effect of different mustard varieties on grain yield

Treatments	Grain yield (g/plot) (Mean ±SE)
T_1	535±2.15
T_2	509±3.76
T_3	495±5.73
T_4	678±2.67
T_5	405±6.45
T_6	501±2.76
T_7	480±1.56
T_8	435±3.89

In a column means with similar letter(s) are not significantly different

T_1: BARI Mustard- 09

T_2: BARI Mustard- 10

T_3: BARI Mustard- 11

T_4: BARI Mustard- 13

T_5: BARI Mustard-14

T_6: BARI Mustard-15

T_7: BARI Mustard-16

T_8: BARI Mustard-17

CHAPTER V
SUMMARY AND CONCLUSION

SUMMARY

A field experiment was carried out in the experimental farm of Sher-e-Bangla Agricultural University, to investigate the incidence of aphid on different mustard variety during the period from November 2015 to March 2016. The experiment was observed in Eight mustard varieties such as T_1 (BARI Sharisha-9), T_2 (BARI Sharisha-10), T_3 (BARI Sharisha-11), T_4 (BARI Sharisha-13), T_5 (BARI Sharisha-14), T_6 (BARI Sharisha-15), T_7 (BARI Sharisha-16) and T_8 (BARI Sharisha-17). The experiment was laid out in a Randomized Complete Block Design with three replications. Data was collected on the number of infested plants/plot, number of branch/plants, number of infested branch/plants, number of pod/plants, number of infested pod/plants, number of aphid per/cm^2 inflorescence, number of pod/plants, number of seeds/pod, and weight of total seeds/plot. Significantly lowest number of infested plant/plot affected by aphid was found in BARI Sharisha-13 and Highest number of affected plants/plot recorded in BARI Sharisha-9.The highest branch infestation by aphids was recorded in mustard variety BARI Sharisha-16 and the lowest branch infestation was recorded in T_4 (BARI Sharisha-13). The highest pod infestation by aphids was recorded in T_1 (BARI Sharisha-9) and the lowest pod infestation was recorded in T_4 (BARI Sharisha-13). The highest number of aphids was recorded in T_1 (BARI Sharisha-9) on the lowest aphid population was recorded in T_4 (BARI Sharisha-13). The highest seeds/pod was recorded from T_4 (BARI sharisha-13) and the lowest seeds/pod was recorded from T_5 (BARI sharisha-14). The highest yield (678 g/plot) was recorded on T_4 (BARI sharisha-13) and the lowest yield (405g) was recorded in T_5 (BARI Sharisha-14).

CONCLUSION

From the study, it may be concluded that incidence of mustard aphid infestation was less in T_4 (BARI sharisha-13).On the other hand incidence of mustard aphid infestation was high in T_5 (BARI sharisha-14). When aphid infestation was higher in T_5 (BARI sharisha-14) then it was observed that pod formation was lower and seed yield also lower. At that time, when aphid infestation was lower in BARI sharisha-13 then, pod formation and seed yield were higher. The overall study revealed that variety may be considered as an eco-friendly pest management practice for mustard by which it could reduce the pest infestation without use of any chemical insecticide. This study reviled that all the varieties more or less infested by aphid and no variety was susceptible against aphid but T_4 was found less succetable to attacked by aphid.

RECOMMENDATION

Performances of different mustard varieties were evaluated against aphid infestation, As per experimental results the farmers are suggested to cultivate BARI MUSTARD – 13. However the experiment needs to be repeated for consecutive years including more management tools for justification of the results.

CHAPTER VI

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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