RESISTANCE SOURCE(S) AMONG MUSTARD VARIETIES /GENOTYPES AGAINST APHID

MOHAMMAD ARIF HOSSAIN

Registration No.: 00936

Semester: January-June, 2007

A THESIS

Submitted To
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, 2008

Approved by

Research Supervisor

Dr. Md. Razzab Ali
Associate Professor
Department of Entomology

Co-supervisor

S. M. Mizanur Rahman
Assistant Professor
Department of Entomology

Dr. Md. Abdul Latif
Chairman
Department of Entomology

CERTIFICATE

This is to certify that the Thesis entitled, "**RESISTANCE SOURCE(S) AMONG MUSTARD VARIETIES /GENOTYPES AGAINST APHID**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh 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 **MOHAMMAD ARIF HOSSAIN** bearing Reg. No.: 00936 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: December, 2008
Place: Dhaka, Bangladesh

Dr. Md. Razzab Ali
Research Supervisor
Advisory Committee


Dedicated TO
MY
Beloved Parents

ACKNOWLEDGEMENT

Thanks to almighty Allah who enabled the author to pursue his education in agriculture discipline, to complete this research works and to prepare this thesis for the degree of MS in Entomology.

The author has pleasure to express his profound respect, deep sense of gratitude, immense indebtedness, sincere appreciation to his reverend teacher and supervisor, Dr. Md. Razzab Ali, Associate Professor Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka for his scholastic guidance, precious suggestions, constructive criticisms, continuous supervision encouragement and untiring assistance in all phases of conducting the research work and preparation of the thesis manuscript.

Sincere appreciation, profound regards and cordial thanks attributed to his respective co-supervisor, S. M. Mizanur Rahaman, Assistant Professor of Entomology, for his continuous inspiration, encouragement, generous help, constructive advice, sympathetic suggestion and his keen interest in his study and for the provision of research facilities.

The author would to express his gratitude and heartfelt respect to Dr.Md. Abdul Latif, Professor Dr. Md. Serajul Islam Bhuiyan and Professor Jahanara Begum, Dr. Md. Mizanur Rahaman, Associate Professor of the Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka for their valuable teaching, inspiration encouragement and advice during the study period.

The author is highly grateful to other teachers and classmates under the Department of Entomology, SAU for their kind co-operation and helps during the study period of MS program and especially thanks to my elder sister Fatema Begum for her co-operations in analyzing data and preparation of manuscript.

The author offers his supreme gratitude to his beloved Father Mohammad Fazlur Rahaman, Mother Mrs. Samsun Nahar and loving sisters who were the constant source of inspiration, encouragement, countless blessing and who sacrificed a lot for higher studies.

December, 2009

The author

LIST OF CONTENTS

LIST OF TABLES

LIST OF PLATES

RESISTANCE SOURCE(S) AMONG MUSTARD VARIETIES /GENOTYPES AGAINST APHID

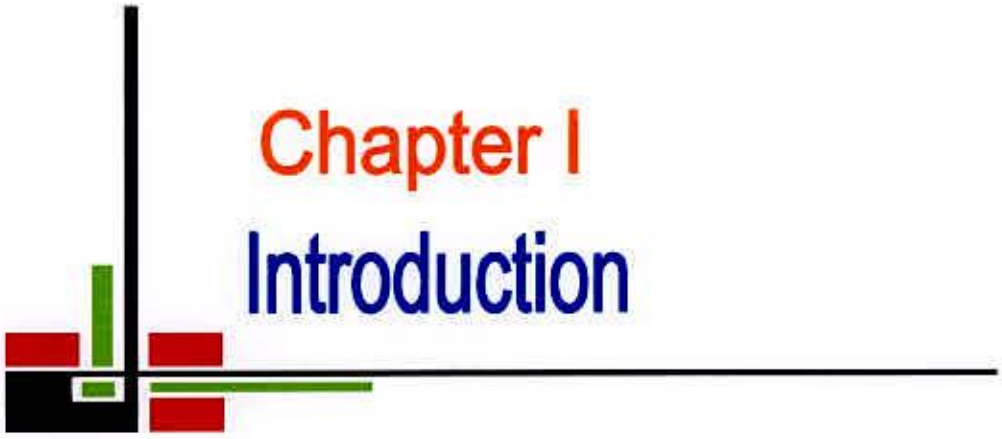
A THESIS

BY

Mohammad Arif Hossain

ABSTRACT

The study on the resistance source(s) among eight mustard varieties/genotypes against mustard aphid, *Lipaphis erysimi* (Kalt.) was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during winter season from November, 2007 to February 2008. The experiment was laid out in randomized complete block design with three replications. The abundance of aphid populations, infestation level, yield and yield attributes among eight mustard varieties were studied to identify the resistance source(s). Out of eight mustard varieties, Tori-7 (545.00) was found as the most preferred host for aphid followed by SAU Sarisha-1, (531.00) where as Agrani (214.00 aphids-plant^{-1}) performed as least preferred host. None of these varieties were found to be resistant in terms of percent plant infestation by aphids and only one variety Agrani (49.43%) was graded as moderately resistant, four varieties BARI Sarisha-6 (53.57%), Safol (56.03%), SS 75 (61.27%) and BINA Sarisha-6 (65.70%) were graded as moderately susceptible, and the varieties Tori-7 (78.17%), SAU Sarisha-1 (76.20%) and BARI Sarisha-9 (70.07%) were graded as susceptible. The highly aphid susceptible variety Tori-7 produced higher percentage of deformed pod (13.48%), and the least performer in all aspects of yield attributes and yield (373.4 kg/ha), but caused maximum yield loss (71.5%). Conversely, the least susceptible variety Agrani produced lower percentage of deformed pod (7.15%), and performed as the best in all aspects of yield attributes and yield (615.5 kg/ha), caused minimum yield loss (46.2%). Considering the national demand of the edible oil and resistance to aphid pest, the mustard variety Agrani should be the preferred variety to cultivate.



Chapter I

Introduction

CHAPTER I

INTRODUCTION

The oilseed crop is very important in agricultural production of Bangladesh. This crop occupied 5,56,000 hectares of land that produce 8,36,000 metric tons of oilseeds (BBS 2008). Among these oilseed crops mustard is the most important, dominant and popular oilseed crop in Bangladesh, which occupied 72,000 hectares of land and produce about 74,000 metric tons of mustard seeds (BBS 2008). So, mustard plays an important role in production of oilseeds in Bangladesh. The cultivated mustard plant (*Brassica* spp.) belongs to the family Cruciferae. Mainly three species of mustard namely, *Brassica campestris*, *Brassica juncea* and *Brassica napus* are cultivated in our country. The production rate of mustard is 356.00 kg/acre in Bangladesh (BBS 2008).

In Bangladesh, mustard crop is cultivated during Rabi season. This crop is infested in the field by several species of insect pests. Among them, the mustard aphid, *Lipaphis erysimi* (Kalt.) is very devastating in bangladesh (Alam *et al.* 1964, Ahmed *et al* 1977, Kabir 1987, Begum 1988, Shahjahan 1994, Husain and Shahjahan 1997). The mustard aphid is distributed in India, Pakistan. Nepal, Bangladesh., USA and many other countries of the World and recognized as a hazardous pest of mustard plant (Arora *et al.* 1969, Jarvis 1970, Srivatava and Srivatawz 1970, Mukhopadhyay and Ghosh, 1979, Husain and Shahjahan 1997). Both nymphs and adults of mustard aphid, *Lipaphis erysimi* cause damage to mustard plants from vegetative to siliqua maturity stage (Brar and Sandhu 1987). Siliqua is the most suitable part for development of

this pest (Tripathi *et al.* 1986), they suck sap from twigs, siliqua, flower buds, flower and leaves of the plants. Maximum damage is caused by aphid at pod formation stage (Brar and Sandhu 1978). The minute greenish insect remains in colonies on young stem, leaves, shoots, inflorescence and pods. The affected leaves become curled and crinkled. As a result, plants loss their vigour and ultimately their growth is stopped. The infested flower fail to set pods, the affected pods get twisted and shriveled. In case of severe infestation, the plant fail to develop pods, they do not mature and unable to produce healthy seeds (Husain and Begum 1984, Kabir 1987, Begum 1988 and Shahjahan 1994).

The *Lipaphis erysimi* (Kalt.) causes enormous qualitative and quantitative losses in rape seed and mustard crop. The seed weight is reduced, which in turns reduces the viability of the seed and the oil content. Production of mustard is very low in Bangladesh in comparison to other countries of Asia. A substantial amount of yield is lost due to aphid infestation. In Bangladesh, no report is available on the estimation of damage caused by mustard aphid.But it has been reported from India that the insect can cause losses of yield ranges from 65.8 to 96.1 percent in *Brassica campestris* and 27.0 to 68.8 percent in *Brassica juncea* (Bakhetia 1983, Kabir 1987, Begum 1988 and Shahjahan 1994). Sometimes loss goes up to cent percent (Bakhetia 1983, Shahjahan 1994).

Generally the farmers of Bangladesh control this pest by the application of chemical insecticides. Though the pest is major in status, the management of this pest through non chemical tactics (cultural, biological, and host plant resistance etc.) undertaken by the researcher throughout the world is scanty. So, the use of chemical regarded to be

most useful measure to combat this pest. But the application of chemical insecticides has got many limitations and undesirable effects (Luckman and Metcalf 1975). It pollutes our environment so much. But we want to "save the environment in order to save to us" So development of resistant mustard variety is urgent. Researchers in this discipline are few in Bangladesh and very slow because suitable rearing and standard screening procedure to evaluate resistance factors are still under study.

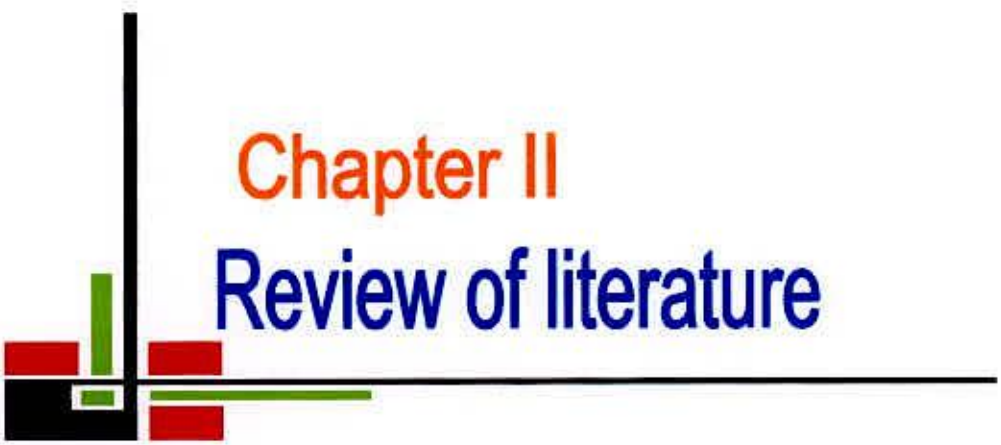
It is the national demand to find out suitable measures to manage this pest and keep the pest population at desirable level. The use of resistant variety of mustard in mustard pest management programme is considered to be economical and safer as compared to the chemical control. To minimize the use of synthetic insecticides and problems arising out of their frequent use, it is very essential to cultivate a resistant and tolerant variety against insect pests specially mustard aphid.

A small number of mustard varieties have been reported to be resistant to the aphid, but most of them have poor agronomic character. In view of this requirement, the present research works were undertaken with a view to establishing the responses of different varieties and one control variety AGRANI to mustard aphid leading to develop a suitable technique for evaluating mustard varieties resistant to *Lipaphis erysimi* (Kalt.).

OBJECTIVES

Considering the above discussion the present study was undertaken to fulfill the following objectives

- To evaluate the different mustard varieties /genotypes against aphid,
- . To determine the level of infestation by aphid among different mustard varieties.
- To study the relationship between infestation level and different yield attributes of different mustard varieties.



Chapter II

Review of literature

CHAPTER II

REVIEW OF LITERATURE

Mustard aphid, *Lipaphis. erysimi* (Kalt.) is an important 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 under the following sub- headings.:

General review of mustard aphid

Geographical distribution

The mustard aphid, *Lipaphis erysimi (*Kalt.) is distributed worldwide (Martin 1983, Pradhan 1994, 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).

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, Kawada 1987). *Lipaphis erysimi* is well known as a serious pest of mustard, cabbage, cauliflower, turnip, kohlrabi, radish, chinese cabbage, rai, toria, Brussels sprout, broccoli, Kale and rutabaga and a minor pest of bean, beet, spinach, pea celery, onion, stock, soybean, cucumber, and potato (Schmutterer 1978, Eastop

1961). Ghosh (1985) reported the host plant range covering many families (Muller and Scholl 1958, Schmutterer 1978 and Hill 1983).

Biology and life history strategies

Taxonomic position of *Lipaphis erysimi* (Kalt.):

Family – Aphididae

Subfamily – Aphidinae

Order – Homoptera

Eastop (1961) and Martin (1983) described the taxonomic features of apterae and alate of *Lipaphis erysimi*. 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, *L. erysimi* (Kalt.) on different varieties of *Brassica* spp. and reported the highest net reproductive rate of 119.38 and lowest 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. juncea*. Fecundity was significantly higher in *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±0.32 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 the 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, *L. erysimi (*Kalt.) 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°C and 57% RH during the second season. The average duration of each generation was 6.04 days during 1996 and 1.15 days during 1997. Furthermore in 1999 they found that mustard aphid, *L. erysimi* (Kalt.) passed through four nymphal instars per generation. The mean nymphal period was 6.84±0.80 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±5.36 and 37.99±8.93 nymphs developed, respectively, in the first and second set of insects under observations.

Kuo (1999) studied that the percentage of alate formation of the turnip aphid, *L erysimi* was investigate at different rearing densities under 5 various constant temperature and photoperiods. The results revealed that interaction between temperature and rearing density, but no effects of photoperiod were 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 densities of the nymph increased at various constant temperatures, 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 (10^0C) temperatures 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 *Lipaphis 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±0.65days) 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°C followed 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 aphid, respectively. The percentage of alatoid nymphs and aphid-infested plants, two factors that were positively correlated, increased as the season progressed. Almost 50% of the total nymphs were alatoid at the end of the season.

Schmutterer (1978) also reported that this 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 *Lipaphis erysimi* on different host plant, viz. cabbage, mustard, cauliflower and radish. They found that the lowest developmental period in radish (9.02 days) and the 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 descending order of mustard (87.65), cauliflower (81.8) and radish (70.6). They also recorded the longevity of apterae as 37.9, 32.7, 35.7 and 28.0 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 1st, 2nd, 3rd, and 4th 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 from alate 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 aphids 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.

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 *Lipaphis erysimi* on different host plant, viz. cabbage, mustard, cauliflower and radish. They found that the lowest developmental period in radish (9.02 days) and the 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 descending order of mustard (87.65), cauliflower (81.8) and radish (70.6). They also recorded the longevity of apterae as 37.9, 32.7, 35.7 and 28.0 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 1st, 2nd, 3rd, and 4th 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 from alate 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 aphids 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.

recommended varieties Agrani, Safal, Sonali and Tori-7 for their resistance to mustard aphid. The results revealed that the mutant BINA-2 had significantly lowest aphid infestation at Mymensingh and Satkhira among the tested mutant /varieties.

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 that this species adopts a kind of maximization of reproduction, which is related to the host plant availability. They also observed a significant positive relationship between body weights with the number of well-developed embryo's.

Roy and Baral (2002) studied the embryonic and population development of *Lipaphis erysimi* 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°C at 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 *Lipaphis erysimi* on mustard. They recorded the best reproductive potential in terms of total and well developed embryos on siliqua formation 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.

recommended varieties Agrani, Safal, Sonali and Tori-7 for their resistance to mustard aphid. The results revealed that the mutant BINA-2 had significantly lowest aphid infestation at Mymensingh and Satkhira among the tested mutant /varieties.

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 that this species adopts a kind of maximization of reproduction, which is related to the host plant availability. They also observed a significant positive relationship between body weights with the number of well-developed embryo's.

Roy and Baral (2002) studied the embryonic and population development of *Lipaphis erysimi* 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°C at 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 *Lipaphis erysimi* on mustard. They recorded the best reproductive potential in terms of total and well developed embryos on siliqua formation 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 *Lipaphis erysimi* (Kalt.) in relation to abiotic factors. Adults appeared on the crop in the last week of February, the population peaked in the third week of mach and aphids disappeared by the third week of April pest population were positively correlated with the average daily temperature, but negatively correlated with relative humidity and rainfall.

Sinha *et al.* (1990) observed the duration of the different stages in the life cycle of *Lipaphis erysimi* under ambient temperature and humidity conditions from December to March (18.7 ± 7.9°C and 62.4±11.0 RH). The nymphal periods showed a positive correlation with ambient periods 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 (24.0days for 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 per plant) and 1998 (76.22 aphid per plant). The ambient sunshine (5.76-8.60 hrs) and the maximum temperature (23.66^{0}C to 25.37^{0}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

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

Sinha *et al.* (1990) observed the duration of the different stages in the life cycle of *Lipaphis erysimi* under ambient temperature and humidity conditions from December to March (18.7 ± 7.9°C and 62.4±11.0 RH). The nymphal periods showed a positive correlation with ambient periods 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 (24.0days for 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 per plant) and 1998 (76.22 aphid per plant). The ambient sunshine (5.76-8.60 hrs) and the maximum temperature (23.66^{0}C to 25.37^{0}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

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 6th March 1990, and 1st January to 13th march), in India. They found that *Lipaphis 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 *Lipaphis erysimi* (414.15 per 10cm 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, Jodebpur, during Rabi season, 1990-91 to find out the effect of 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 21 January to 28 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^{0}C and at 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* 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 mean maximum temperatures 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, *L. erysimi* whose infestation was severe from the January to the middle February.

Sinha *et al.* (1989 & 1990) observed the appearance of *Lipaphis erysimi* in the third week of December with an increasing pattern in January / February which reached to a peak in the mid of February in Bihar, India. Temperature and humidity were found important by them for aphid multiplication but frequent rainfall kept the population density low apart 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 *Lipaphis 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 favoured by maximum and minimum temperature of 21.4-22.8^{0}C and 5.9-7.6^{0}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 peak in the third week of March and

disappeared by the third week of April (Nasir *et al.*1998). They found the aphid population to be positively correlated with the average daily temperature, but negatively 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 15^0C with RH 62.5 – 93.5 %.

Susceptibility of mustard varieties to aphid

Many scientists have done enormous number of research work 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 diallel cross involving 5 genotypes resistant to mustard aphid and 4 high-yield susceptible genotypes, none of the parental 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* (Kaltenbach). None of the genotypes tested was found to be immune; however, five genotypes (GSL-1 (*B. napus*), PC-5 (*B. carinata*), T-27 (*Eruca sativa*) [*E. vesicaria*], local genotype (*B. tournefortii*) and T-6342) 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 and third weeks of November, and with minimum 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* germplasms against the mustard aphid, *Lipaphis erysimi,* 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 (1992a) conducted that results are presented of field experiments, conducted in Ludhiana, India in 1987-89, 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 1987-89 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, *Lipaphis erysimi*. Aphid infestation index (AII, 0-5 scale) was calculated at full flowering and full pod formation stages. Banarsi, Rai and Rohini were considered highly resistant to aphid infestation, with AII of 0.56-0.67 and 0.79-069 in 2001/02 and 2002/03, respectively. RK-819, Krishna, RK-9304, RGN-19, RK-9801, RK-90, Basanti, SBG-51, Urvashi and MLN-157 were moderately resistant, with AII of 2.1-2.95 in both years. Varuna, Vaibhav, Vardan and UPN-9 were susceptible, with AII 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*], *Diplotaxis siifolia, B. tournefortii, B. campestris*, and lines/cultivars of *B. juncea* (10), *B. napus* (10) *and B. carinata* (10) for resistance to mustard aphid (*Lipaphis erysimi*). All the *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 *Diplotaxis siifolia* 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-I, BSH-I, DBS-5, KOS-I and YSK-151 for resistance to mustard aphid, *Lipaphis erysimi*, revealed that the cultivars were not infested at pre-bloom stage. The maximum aphid infestations of 20.96 and 100.66 aphids per plant were recorded at bloom and post-bloom stages, 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-I 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 cultivar.

Rangre *et al.* (2002) carried out a field trial to screen various mustard cultivars, viz. KS-101, KS-102, KS-103, KS-104, KOS-1, BS-1, BS-2, BSH-1, DBS-5, and YSK-151 for the presence of the mustard aphid, *L. erysimi*. None of the cultivars studied were infested with the aphid at pre-bloom stage of the crop. During post-bloom, maximum aphid population per plant (97.3) was recorded from yellow sarson 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 2000-01. 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, Pusa Basant, 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 resistance 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 F< sub>1</ sub> hybrids from a diallel cross involving 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 colour did not influence per cent plant infestation. However, glossiness of leaf and stem influenced mustard aphid incidence at early stages of infestation. Genotype RH7361, with creamish coloured 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 RLM198 registered lower infestation rate. The hybrid B85 x RLM198 (R x 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, siliqua length; 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 under heavy incidence of pest

or under no choice conditions. Hence, concrete efforts need to be made to enhance the available level of resistance before their use as donor parents for the development of resistant genotypes. Increasing the available level of resistance by increasing the frequency of resistant alleles in additive fashion involving comparatively resistant parents is recommended. Diallel selective mating and the use of bi-parental mating followed by seedling screening in segregating generations are suggested as a means of developing resistant genotypes.

Malviya and Lal (2000) showed that screening of 78 *Brassica* germplasms based on the Aphid Infestation Index 15 *Brassica* germplasms were promising against the mustard aphid, *Lipaphis erysimi* (Kalt.) under field conditions during rabi 1997-98 in Faizabad, India.

Brar *et al.* (1976) investigated sixty six strains of raya and brown sarson against Mustard aphid under field as well as artificial condition. They reported 17 strains as 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 at the flowering stage.

Bakhetia and Labana (1978) developed some principles 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 plants and seed yield of cultivars.

Brar and Sandhu (1987) evaluated some strains of *B. campestris* and *B. juncea* against *L. erysimi* under field and laboratory condition. They identified some varieties 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 (1982) 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, Pb-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 there existed significant difference in the duration oft 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, Rye-75-1, and Pusakalyani, Brown sarson K-l, Varuna and Rye-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-l was the most susceptible to aphids.

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 arc 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) screened 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-128-17, 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 Phadke (1987) investigated 50 *Brassica* genotypes for susceptibility to aphid in the field. Among the genotypes *B. nigra* (Tall), RLM-29, RLM-29/25, RLM-84, RLM-171 and P-l 1/7-1 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. *Eruca 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%).

Malik (1988) compared the genotypes belonging to species of *B. juncea, B. napus, B. nigra* and 3 strains of *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 (2002) conducted an experiment at pulses and oilseeds research station, Berhampore, Murishidabad, West Bengal, India during the rabi season of 1992-93, 1993-94 and 1994-95 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 loss (46.12%) due to infestation by *Myzus persicae* and *L. erysimi*, followed by brown sarson (BSH-1; 43.58%), *B. juncea* (Varuna) and *B. napus* (HPN-1) showed lower susceptibility, with yield losses from 30.90 to 36.01 percent .*B. carinta* (HPC) was the least susceptibility with 22.94% yield loss.

Yield loss due to mustard Aphid Infestation

Rohila *et al.* (1987) conducted a four year investigation with six *Brassica* for their resistance to *L. erysimi* (Kalt.). The investigators used the yield loss as the criteria of

resistance and reported the following decreasing order of resistance *Eruca sativa* T-27 (16.44% yield loss); *B. juncea* parkesh (23.64%); RH30 (27.31%); *B. campestris* brown sarson BSH1 (32.73%), yellow sarson YSPb-24 (34.18%) and *B. napus* HNS 3(61.32%).

Sekhon and Ahman (1992) expressed that *L. erysimi* (Kallt.) 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 1993-94 to assess the loss due 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 rabi season of 1994-95 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 populations.

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. RW5453-B-2 seemed to be suitable for general cultivation.

Anonymous (1995) conducted a field experiment with eleven varieties/mutants of mustard to measure the loss of yield due to aphid infestation. The mutants/varieties

included in the test were Agrani, Safal, BINA-2, NAP-3, Sampad, SS-75, Tori-7, Tori-68, Sangam and BS-5. The investigators reported that the mutants/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 1991-94 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* (HPN-1) Showed lower susceptibility with yield losses ranging from 30.90 to 36.01%. *B. carinata* (HPC-1) was the least susceptible cultivar with 22.84% yield loss.

Agarwal *et al.* (1996b) carried out a field experiment under the agro climatic 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, siliqua length, seeds/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.

Influence of morphological characters of mustard plant on aphid infestation

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

Srivastava *et al.* (1972) carried out a field experiment to study the ecology of *L. erysimi* and the incidence of these pests on 14 varieties of mustard. The data was recorded as weekly interval from 14 days after sowing in relation to plant height, temperature and relative humidity. The maximum incidence of *L. erysimi* recorded when plants were 60-120 cm tall, the temperature was 17-18°c and relative humidity was 61-83%.

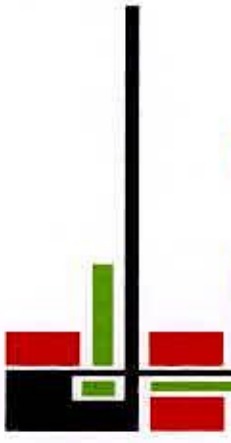
Brar and Sandhu (1978) carried an experiment to observe susceptibility of different varieties of *B. campestris* and *B. juncea* to aphids. They concluded that the varieties having taller plants were less susceptible to aphids than shorter ones.

Kabir (1987) investigated that the taller genotypes had comparatively less susceptible to aphid.

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 1989-90 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.* (1996a) 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 *L. erysimi.*



Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The present study was conducted on varietal screening of mustard against aphid, *Lipaphis erysimi* (Kalt.) The research work was conducted during the period from November 2007 to February 2008 (Rabi season at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh.

3.1.1. Treatments

The eight varieties/genotypes of mustard collected from the different sources used in the study are presented in Table 1. Each variety of which was considered as an individual treatment.

Table 1. Particulars of eight mustard varieties /genotypes used under the present trial

Treatments	variety	Source of availability
V_1	SAU Sarisha -1	Sher-e-Bangla Agricultural University (SAU)
V_3	BARI Sarisha (Tori-7)	Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh
V_4	BARI Sarisha-9 (Tori rape)	
V7	BARI Sarisha-6 (Dhali)	
V_8	BARI Sarisha (SS-75)	
V_2	BINA Sarisha -6	Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh
V_6	BINA Sarisha (Safol)	
V_7	BINA Sarisha (Agrani)	

3.1.2. Location of experimental site

The experimental plot were located in the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka situated at latitude 23.64^0 N and 90.23^0 E with

an elevation of 8.45 meter from the sea level. Laboratory studies were done in the laboratory of Entomology Department, SAU. Required materials and methodology were described under the following sub headings.

.3.1.3. Soil of the experiment field

The soil of the experimental field area was under the Agro Ecological zone of Madhupur Tract (AEZ-28) with pH 5.8-6.5, CEC 25-28 (Haider *et al.*1991).

3.1.4. Land preparation

The soil was well prepared, good tilth was ensured for commercial crop production. The target land was divided into 24 equal plots (3m x 2m) with plot to plot distance 0.5 m; block to block distance 1.0 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 lands were spaded and larger clods were broken into smaller pieces. After ploughing and laddering and the stubbles and uprooted weeds were removed and then the land was ready.

3.1.5. Fertilizer and manure

Recommended fertilizers were applied at the rate of urea 150 kg/ha, 75 kg/ha Triple Super Phosphate (TSP) and 150 kg Muriate of Potash (MP)/ha, Gypsum 75 kg/ha, ZnO 5 kg/ha, boric acid 10 kg/ha and cowdung 1.5 ton/ha (BARC 1999). The entire amount of TSP, MP, Gypsum and half of urea were applied at the time of final land preparation. The rest of urea was applied as top dressing during irrigation at 40 days after sowing (DAS).

3.1.6. Design of experimental and layout

The experiment was laid out in a Randomized Complete Block Design with 3 replications.

3.1.7. Collection of seeds, and sowing

The seeds of eight selected mustard varieties SAU Sarisha-1, BINA Sarisha -6, TORI-7, BARI Sarisha-6, BARI Sarisha-9, SAFOL, AGRANI, SS75 were collected from the Department of Genetics and plant Breeding, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh and local market. Each of these eight selected mustard varieties was treated as an individual treatment. Before sowing seeds the germination test was done and 90% germination was found for all varieties. Seeds were then directly sown in the 24th November in the field @ 8 kg /ha. After germination, the seedlings were spayed with water by a hand sprayer. Soil was sprayed 3 or 4 days for a week.

3.1.8 Intercultural operation

Weeding and thinning

Various types of weeds were found in the crop field. Weeding and thinning were done as needed during the growing period. Two times flood irrigation was given at vegetative stage in the field.

3.1.9. Data collection and calculation

For data collection six plants per plot were randomly selected and tagged. Data collection was started at 41 days after sowing. All the data were collected once a week. The data were collected as on different parameters such as number of aphid per plant at, number of aphid infested plants, branch, inflorescence, pod, number of deformed pod, height of healthy and infested plants at 55 DAS and 62 DAS, length of healthy and infested pod, total no of branch, pod and 1000 seed wt., total yield (g) per plot and yield (kg ha^{-1}), and percentage of yield loss by calculation.

3.1.10. Percent of aphid infested plant by number

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

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

Percent of aphid infested branch

The total number of infested and uninfected branch at flowering and pod forming stage were counted from randomly selected, 6 plants of three rows. Thus the percentage of infested branch by aphid was calculated using following formulae:

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

Percent of aphid infested inflorescence

The total number of aphid infested and un-infested inflorescence at flowering and pod forming stage were counted from randomly selected 6 plants of three rows. Thus the percentage of infested inflorescence by aphid was calculated using following formula:

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

Percent of aphid infested pod

The total number of aphid infested and un-infested pod were counted from randomly selected 6 plants of three rows. Thus the percentage of infested pod by aphid was calculated using following formula:

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

Percent of aphid infested deformed pod

The total number of infested and un-infested deformed pod at flowering and pod forming stage were counted from randomly selected 6 plants of three rows. Thus the percentage of infested deformed pod by aphid was calculated using following formula:

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

3.1.12. Number of aphid

The number aphid on 8 randomly selected plants from each plot was counted at 55 DAS and 62 DAS. The top 10 cm apical twigs of three randomly selected inflorescence of selected plants were cut and brought to the laboratory in bags separately for counting the number of aphids 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 inflorescence were cheeked carefully, so that, single aphid could not escape at the time of counting.

3.1.13. Yield and yield contributing characters

The crops were harvested at full maturity stage from 19th February to 26th February 2008. For the purpose of the study of yield contributing character viz. data on number of pods per plant and number of infested pod per plant, and yield of 5 healthy plants and 5 infested plants were recorded.

Calculation of yield loss

$$\% \text{ Yield loss} = \frac{\text{Yield of 5HP-5 IP}}{\text{Yield of 5 HP}} \times 100$$

Here, HP= Healthy Plants
IP= Infested Plants

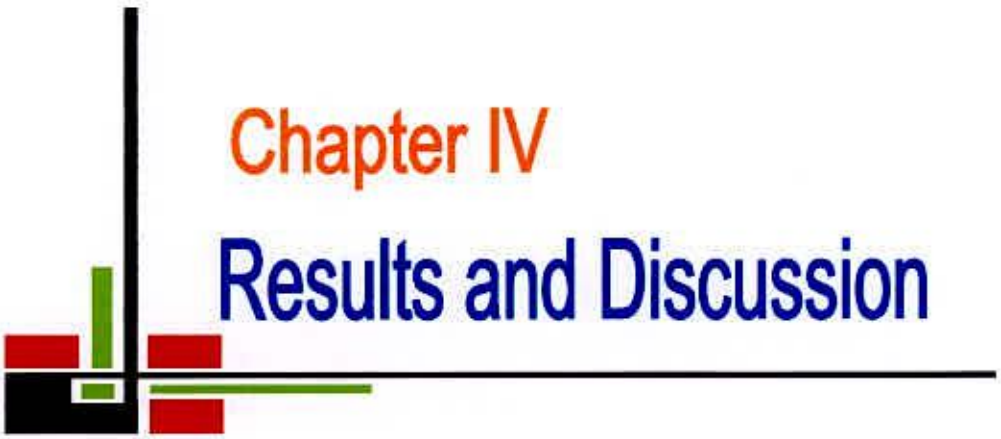
Plant Grading

Total number of mustard plants and the number of infested plant (s) in each plot were counted. The percentage of aphid infested plants was then graded by grading designation used by Rashid *et al.* (2002) as follows:

Grade designation	% infestion	Letter grade
Resistant	1-25	R
Moderately Resistant	26-50	MR
Moderately Susceptible	51-75	MS
Susceptible	Above 75	S

3.1.14. Statistical analysis

The data obtained from different parameters were statistically analyzed using MSTAT program. The means of statistically significant parameters were separated by using Duncan's Multiple's Range Test (DMRT) at 5% and 1% level. The correlation studies were also done to make relationship among different parameters.



Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during rabi season of 2007-08 to evaluate eight mustard varieties/genotypes namely SAU Sarisha-1, BINA Sarisha-6, TORI-7, BARI Sarisha-6, BARI Sarisha-9, SAFOL, AGRANI, SS 75 to find out the resistance source(s) against mustard aphid. The results have been presented and discussed, and possible interpretations have been given under the following sub-heading:

4.1. Incidence of aphid infestation among different mustard varieties

Statistically significant variations were observed in the incidence of aphid population by number among eight selected mustard varieties/genotypes used under the present trial and represented in Table 2. The mean number of aphid per plant ranged from 214.00 to 420.5 at 55 days after sowing (DAS) and 227.00 to 545.00 at 62 DAS. At 55 DAS, the highest incidence of aphid population by number per plant was recorded in the variety Tori-7(420.5). This was statistically similar with the variety SAU Sarisha-1 (401.00) followed by SS 75 (340 aphids-plant^{-}). This was also followed by Safol (306.50 aphids-plant^{-1}). On the other hand, the lowest incidence of aphid by number per plant was recorded in the variety Agrani (214.00) followed by BARI Sarisha-6 (247.00 aphids-plant^{-1}) followed by BARI Sarisha-9 (258.50 aphids-plant^{-1}). This was also followed by BINA Sarisha-6 (290.00 aphids-plant^{-1}).

More or less similar trend but higher incidence of aphid population by number per plant was also observed at 62 DAS and the highest incidence was recorded in Tori-7, which was statistically similar with SAU Sarisha-1 (531.00 aphids-plant^{-1}) (Table 1). On the other hand, the lowest incidence was recorded in the variety Agrani(227.00),

which was statistically different from all other varieties followed by BARI Sarisha-6 (302.00 aphids-plant^{-1}). This was followed by BARI Sarisha-9 (377.00 aphids-plant^{-1}). As a result, the order of trends in the incidence of aphid population in terms of comparative host preference among eight mustard varieties was Tori-7 > SAU Sarisha-1 > SS 75 > Safol > BINA Sarisha-6 > BARI Sarisha-9 > BARI Sarisha-6 > Agrani.

Table 2. Incidence of aphid population in the field of different mustard varieties/ genotypes during winter

Variety	Incidence of aphid population (No/plant)	
	55 DAS*	62 DAS
SAU Sarisha-1	401.50 a	531.00 a
BINA Sarisha-6	290.00 c	465.50 b
Tori-7	420.50 a	545.00 a
BARI Sarisha-9	258.50 d	377.00 c
BARI Sarisha-6	247.00 d	302.00 d
Safol	306.50 c	472.00 b
Agrani	214.00 e	227.00 e
SS 75	340.00 b	527.00 a
$LSD_{0.01}$	31.565	52.88
CV%	4.60%	5.23%

In a column means followed by same letter(s) do not differ significantly at 1% by DMRT
*DAS = Days after sowing

From the above findings it is revealed that Tori-7 showed the most preferred host followed by SAU Sarisha-1, whereas Agrani, BARI Sarisha-6 and BARI Sarisha-9 performed as least preferred host for mustard aphid in terms of incidence of aphid population by number. About similar works 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. Similarly Kabir (1987) reported that out of 12 mustard germplasms BINA-M-46,

BINA-M-59, M-128-17, 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

.4.2. Incidence of aphid infested branch among different mustard varieties

Statistically significant variations were observed and recorded in terms of incidence of aphid infested branch in the field of eight different mustard varieties used under the present trial represented in Table 3. At 41 DAS, the incidence of aphid infested branch among different mustard varieties ranged from 16.60 % to 40.00%. The highest incidence of plant infestation was recorded in the variety Tori-7, which was significantly similar with SAU Sarisha-1 (34.00%) followed by SS 75 (28.50%) and BARI Sarisha-9 (28.30%). On the other hand, the lowest incidence of aphid infested branch was recorded in the variety Agrani and Safol, which was significantly similar with BINA Sarisha-6 (18.10%) and BARI Sarisha-6 (22.20%).

More or less similar trends of results in terms of incidence of percent aphid infested branch among different mustard varieties were also observed and recorded at 49 DAS, 55, 62, 69and 74 DAS Considering the mean incidence, the incidence of aphid infested branch among different mustard varieties was ranged from 52.38% to 78.48%, where the highest incidence of branch infestation was recorded in the variety Tori-7, which was significantly similar with SAU Sarisha-1 (73.00%) followed by BARI Sarisha-9 (68.78%) (Table 3). On the other hand, the lowest incidence of aphid infested branch was recorded in the variety Agrani, which was significantly identical with BARI Sarisha-6 (59.35%) followed by Safol (60.71%). As a result, the order of trend in the mean incidence of aphid infested branch among eight mustard varieties is

Tori-7 > SAU Sarisha-1 > SS 75 > Safol > BINA Sarisha-6 > BARI Sarisha-9 > BARI Sarisha-6 > Agrani.

Table 3. Incidence of aphid infested branch in the field of different mustard varieties throughout the cropping season

Variety	Incidence of aphid infested branch (%)						
	41 DAS	48 DAS	55 DAS	62DAS	69 DAS	74 DAS	Mean
SAU Sarisha-1	34.00a	68.40a	71.40b	89.70a	88.50ab	86.00a	73.00 a
BINA Sarisha-6	18.10c	45.50b	77.70ab	97.00a	85.70ab	77.50ab	66.31bc
Tori-7	40.00a	66.60a	87.50a	100.0a	88.80a	88.00a	78.48a
BARI Sarisha-9	28.30b	44.40b	85.70a	88.80ab	87.50ab	78.00ab	68.78ab
BARI Sarisha-6	22.20c	39.70b	70.00ab	81.80b	74.70ab	67.70b	59.35cd
Safol	16.60c	42.50b	71.40ab	88.80ab	75.00b	70.00ab	60.71bc
Agrani	16.60c	25.00c	55.50b	83.30ab	73.70ab	62.00b	52.38d
SS75	28.50b	44.40b	72.70b	76.50ab	75.70ab	75.00ab	62.13bc
$LSD_{0.01}$	6.022	9.603	21.46	15.81	15.81	18.59	8.228
CV%	10.30%	8.19%	11.82%	7.57%	6.21%	9.03%	5.11%

Means followed by same letter(s) do not differ significantly at 1% by DMRT; *DAS = Days after sowing.

From the above findings it is revealed that among the eight varieties/genotypes of mustard, none was found to be resistant to aphid. In respect of incidence of aphid infested branch, the variety Agrani can be identified as least preferred host to mustard aphid. The variety BARI Sarisha-9, BINA Sarisha-6, SS 75, Safol and BARI Sarisha-6 can be identified as moderately preferred; Tori-7 and SAU Sarisha-1 can be identified as most preferred host to aphid infestation. The percent branch infestation was sharply increased with the increase of the plant ages and reached the peak at 62 days after sowing and then gradually decreased. This result was in agreement with those of Islam (1991).

4.3. Incidence of aphid infested plants among different mustard varieties

Statistically significant variations were observed in the incidence of aphid infested plants throughout the growing season in the field of different mustard varieties and the recorded results were represented in Table 4. At 41 DAS, the incidence of aphid infested plants among different mustard varieties ranged from 35.33 to 54.33%. The highest incidence of plant infestation was recorded in the variety Tori-7, which was significantly similar with 44.93% in SAU Sarisha-1, 43.83% in Safol and 42.80% in both BINA Sarisha-6 and BARI Sarisha-9. On the other hand, the lowest incidence of aphid infested plants was recorded in the variety Agrani, which was also significantly similar with BARI Sarisha-6 (36.80%) and the genotype SS 75 (38.87%).

More or less similar trends of results in terms of incidence of percent aphid infested plants among different mustard varieties were also observed and recorded at 49, 55, 62, 69 DAS and 74 DAS, but percent incidences were increased with the increase of the plant ages (Table 4). The mean incidence, aphid infested plants among different mustard varieties was ranged from 49.43% to 78.17%, where the highest incidence of plant infestation was recorded in the variety Tori-7, which was significantly similar with SAU Sarisha-1 (76.20%) followed by BARI Sarisha-9 (70.07%) On the other hand, the lowest incidence of aphid infested plants was recorded in the variety Agrani, which was significantly identical with BARI Sarisha-6 (53.57%) and Safol (56.03%). As a result, the order of trend in the mean incidence of aphid infested plants per plot among eight mustard varieties is Tori-7 > SAU Sarisha-1 > BARI Sarisha-9 > BINA Sarisha-6 > SS 75 > Safol > BARI Sarisha-6 > Agrani.

Table 4. Incidence of aphid infested plants in the field of different mustard varieties grown in winter

Variety	Incidence of aphid infested plants (%)							
	41DAS	48DAS	55DAS	62DAS	69DAS	74DAS	Mean	Grade
SAU Sarisha-1	44.93ab	66.10 a	81.43 a	91.60a	89.10ab	84.03b	76.20a	S
BINA Sarisha-6	42.80ab	50.80ab	70.20bc	79.27bc	76.03c	75.30cd	65.70bc	MS
Tori-7	54.33 a	57.80ab	73.97ab	97.20a	94.30a	91.27a	78.17a	S
BARI Sarisha-9	42.80ab	58.57ab	62.8bcd	89.90ab	85.80b	80.67bc	70.07b	MS
BARI Sarisha-6	36.80 b	52.13ab	57.37cd	65.07de	56.63de	53.40e	53.57e	MS
Safol	43.83ab	43.77b	58.20cd	73.50cd	61.53d	55.17e	56.03de	MS
Agrani	35.33 b	46.27b	53.47d	56.77e	52.63e	51.67e	49.43e	MR
SS75	38.87 b	56.93ab	56.43cd	74.77cd	72.57c	71.50d	61.27cd	MS
$LSD_{0.01}$	13.26	15.21	13.93	10.82	6.812	6.673	6.097	
CV%	10.35%	6.86%	5.09%	8.21%	8.19%	7.15%	7.94%	

Means followed by same letter(s) do not differ significantly at 1% by DMRT; *DAS = Days after sowing.

Resistant (R): 1-25% plant infestation; Moderately resistant (MR): 26-50% plant infestation; Moderately Susceptible (MS): 51-75% plant infestation and Susceptible (S): Above 75% plant infestation (Rashid *et al.* 2002).

From the above findings it is revealed that among the eight varieties/genotypes of mustard, none was found to be resistant to aphid. According to the results of the present study the varieties/genotypes of mustard were graded for their level of susceptibility to mustard aphid according to Rashid *et al.* (2002). The variety Agrani can be regarded moderately resistant to mustard aphid. The variety BARI Sarisha-9, BINA Sarisha-6, SS 75, Safol and BARI Sarisha-6 can be regarded as moderately susceptible; Tori-7 and SAU Sarisha-1 can be graded as susceptible to aphid infestation. The aphid infestation showed a sharp rise and reached the peak at 62 days after sowing. During this period almost all the varieties/genotypes of mustard had

borne flowers and started setting pods. This physiological stage of the mustard plant might be more favorable to aphid attack.

This results were in agreement with those of Husain and Begum (1984)) and Husain and Shahjahan (1997), Kabir (1987), Begum (1988), who also regarded Tori-7 as highly susceptible to mustard aphids.

4.4. Incidence of aphid infested inflorescence among different mustard varieties

Statistically significant variations were observed and recorded in the incidence of aphid infested inflorescence in the field of eight mustard varieties used under the present trial represented in Table 5. At 41 DAS, the incidence of aphid infested inflorescence among eight mustard varieties ranged from 33.33% to 60.33%, where the highest incidence of aphid infested inflorescence was recorded in the variety Tori-7, which was significantly similar with SAU Sarisha-1 (34.00%) followed by SS 75 (47.77%). On the other hand, the lowest incidence of aphid infested inflorescence was recorded in the variety Agrani, which was significantly similar with BARI Sarisha-6 (34.70%), Safol (36.93%) and BINA Sarisha-6 (37.50%).

More or less similar trends of results in terms of incidence of percent aphid infested branch among different mustard varieties were also observed and recorded at 48 DAS and 55 DAS, but percent incidences were increased with the increase of the plant ages. Considering the mean incidence, the incidence of aphid infested inflorescence among eight mustard varieties was ranged from 44.00% to 73.87%, where the highest incidence was recorded in the variety Tori-7, (plate 4)which was significantly similar with SAU Sarisha-1 (70.57%) followed by BARI Sarisha-9 (62.28%) (Table 5). On the other hand, the lowest incidence was recorded in the variety Agrani, which was significantly identical with BARI Sarisha-6 (44.73%) and Safol (49.67%) (Plate1& 2).

As a result, the order of trend in the mean incidence of aphid infested inflorescence among eight mustard varieties is Tori-7 > SAU Sarisha-1 > BARI Sarisha-9 > BINA Sarisha-6 > SS 75 > Safol > BARI Sarisha-6 > Agrani.

Table 5. Incidence aphid infested inflorescences in the field of different mustard varieties through out the cropping Season.

Variety	Incidence of aphid infested inflorescences (%)			
	41 DAS	48 DAS	55 DAS	Mean
SAU Sarisha-1	53.00 a	69.53 ab	89.23 ab	70.57 ab
BINA Sarisha-6	37.50 bc	59.50 bc	80.97 abc	59.30 bc
Tori-7	60.33 a	68.80 ab	92.53 a	73.87 a
BARI Sarisha-9	38.87 b	74.57 a	73.40 abc	62.28 bc
BARI Sarisha-6	34.70 d	37.50 bc	62 .00 bc	44.73 cd
Safol	36.93 bc	53.40 c	62.37 bc	49.67 cd
Agrani	33.33 bc	28.87 d	60.47 c	44.00 d
SS 75	47.77 c	68.60 ab	69.03 ab	55.10 cd
$LSD_{0.01}$	9.470	9.470	24.51	12.62
CV%	9.58%	7.82%	13.68%	12.57%

In a column means followed by same letter (s) do not differ significantly at 1% by DMRT
*DAS = Days after sowing

From the above findings it is revealed that among the eight varieties/genotypes of mustard, none was found to be resistant to aphid. In respect of incidence of aphid infested inflorescence, the variety Agrani can be identified as least preferred host to mustard aphid. The variety BARI Sarisha-9, BINA Sarisha-6, SS 75, Safol and BARI Sarisha-6 can be identified as moderately preferred; Tori-7 and SAU Sarisha-1 can be identified as most preferred host to aphid infestation. The percent inflorescence infestation was sharply increased with the increase of the plant ages. This result was in harmony with Islam (1991), who also regarded that the highest incidence of aphid infested inflorescence recorded in Tori-7.

Plate 1. Experimental field of Mustard at Sher-e-Bangla Agricultural University

Plate 2. Healthy inflorescence of mustard(Agrani)

Plate 3. Severely aphid infested inflorescence of mustard

4.5. Incidence of aphid infested pod among different mustard varieties

Statistically significant variations were observed and recorded in the incidence of aphid infested pod in the field of eight mustard varieties used under the present trial represented in Table 6. At 41 DAS, the incidence of aphid infested pod among eight mustard varieties ranged from 7.83% to 18.70%, where the highest incidence of aphid infested pod recorded in the variety Tori-7 and the lowest incidence was recorded in the variety Agrani.

More or less similar trends of results in terms of incidence of percent aphid infested pod among eight mustard varieties were also observed and recorded at 48 DAS and 55 DAS, but the incidences increased with the increase of the plant ages. The highest ranges of incidence of aphid infested pod were observed at 62 DAS and the incidences were ranged from 43.74% to 81.35%.

Considering the mean incidence, the incidence of aphid infested pod among eight mustard varieties was ranged from 32.25% to 57.75%, where the highest incidence was recorded in the variety Tori-7, which was significantly similar with SAU Sarisha-1 (54.02%). On the other hand, the lowest incidence was recorded in Agrani (32.25%) followed by BARI Sarisha-6 (43.20%). As a result, the order of trend in the mean incidence of aphid infested pod among eight mustard varieties is Tori-7 > SAU Sarisha-1 > BARI Sarisha-9 > BINA Sarisha-6 > SS 75 > Safol > BARI Sarisha-6 > Agrani.

Table 6. Incidence of aphid infested pod in the field of different mustard varieties throughout cropping season

Variety	Incidence of aphid infested pod (%)						
	41 DAS	49 DAS	55 DAS	62 DAS	69 DAS	74 DAS	Mean
SAU Sarisha-1	29.8a	35.51ab	48.87ab	76.27ab	75.16ab	66.71a	54.02ab
BINA Sarisha-6	16.8bc	20.29bcd	53.94ab	69.73bc	68.42bc	58.63bc	46.31c
Tori-7	18.7ab	37.40a	59.46a	81.35a	80.91a	68.62a	57.75a
BARI Sarisha-9	15.8bc	34.01abc	56.62a	79.14a	72.70ab	64.76ab	53.33b
BARI Sarisha-6	18.27b	25.72abcd	55.03ab	62.27c	47.42d	50.46d	43.20c
Safol	21.60ab	17.18d	50.25ab	64.58c	60.40c	52.73cd	44.47c
Agrani	7.85 c	18.08cd	42.34b	43.74d	36.07e	41.91e	32.25d
SS 75	18.01b	22.2abcd	52.18ab	66.84c	66.75bc	55.70cd	44.88c
$LSD_{0.01}$	8.761	15.20	11.70	7.653	9.561	6.844	3.754
CV%	9.88	9.61	7.53	4.48	8.54	6.06	6.31

In a column means followed by same letter (s) do not differ significantly at 1% by DMRT
*DAS = Days after sowing.

From the above findings it is revealed that among the eight varieties/genotypes of mustard, none was found to be resistant to aphid. In respect of incidence of aphid infested pod, the variety Agrani can be identified as least preferred host to mustard aphid, whereas Tori-7 (plate5) and SAU Sarisha-1 can be identified as most preferred host to aphid infestation. This result was harmony with Islam (1991), who also regarded that the highest incidence of aphid infested pod was recorded in Tori-7.

4.6. Incidence of aphid infested deformed pod among different mustard varieties

Statistically significant variation was observed in the infested of percent aphid infested deform pod of different mustard varieties used the present trial represented in Table 7. More or less similar trends of percent aphid infested deformed pod were recorded at 62 DAS, 69 DAS and 76 DAS. Among different ages of the plant, the highest ranges (8.93 % to 16.91%) of incidences of aphid infested pod were recorded at 62 DAS and it was decreased with the increase of the plant age. Considering the

mean incidence, the aphid infested deformed pod was ranged from 7.15% to 13.48%, where the highest incidence was recorded in the variety Tori-7 (plate 3), which was statistically different from other varieties and the lowest percentage of aphid infested deformed pod was recorded in Agrani (Plate 4).

Table7. Incidence of aphid infested deformed pod among different mustard varieties grown in winter

Variety	Incidence of aphid infested deformed pod (%)			
	62 DAS	69 DAS	76 DAS	Mean
SAU Sarisha-1	11.70 b	11.17 ab	6.43 b	9.77 b
BINA Sarisha-6	10.16 b	8.61 bcd	8.10 ab	8.95 bc
Tori-7	16.91 a	13.27 a	10.37 a	13.48 a
BARI Sarisha-9	10.60 b	10.70 abc	7.50 ab	9.60 bc
BARI Sarisha-6	9.80 b	6.97 d	5.80 b	7.52 bc
Safol	9.80 b	7.70 cd	6.86 b	8.17 bc
Agrani	8.93 b	5.92 d	6.56 b	7.15 c
SS 75	9.89 b	7.94 bcd	6.83 b	8.22 bc
$LSD_{0.01}$	3.138	4.507	2.074	2.449
CV%	14.07	14.07	8.93	8.19

In a column means followed by same letter (s) do not differ significantly at 1% by DMRT
*DAS=Days after sowing.

From the above findings it is revealed that the highly susceptible variety Tori-7 produced higher percentages of deformed pod due to attack by the higher number aphids. Conversely, Agrani produced lower percentage of deformed pod because of the lower incidence of the aphid population.

Plate 4. Uninfested healthy pods (Agrani)of mustard .

Plate 5. Deformed pods of mustard (Tori-7) caused by aphids

4.7. Influence of aphid infestation on yield attributes of different mustard varieties

Significant variation was recorded in terms of height per plant for different mustard varieties evaluated against aphid under the present trial represented in the Table 8. In terms of height on single plant in cm, the maximum height was recorded at 62 DAS in the variety of Agrani. This was 148.0 cm which was significantly different from all other varieties followed by BARI Sarisha-6 (129.7cm), Safol (125.0cm), BINA Sarisha-6(117.0 cm) and the minimum height Tori-7 (103.0cm) which was almost statistically similar with other varieties followed SAU Sarisha-1 (113.0cm), BARI Sarisha-9 (109.0cm), SS75 (109.3cm). As a result, the trend of results in terms of height per plant among eight mustard varieties is Agrani > BARI Sarisha-6 > Safol > SS 75 > BINA Sarisha-6 > BARI Sarisha-9 > SAU Sarisha-1 > Tori-7.

Significant variation was recorded in terms of number of branch per plant at 62 DAS for eight mustard varieties evaluated against aphid under the present trial represented in the table 8. In terms of number of branch per plant, the maximum number of branch was recorded in the variety of Agrani and this was 10.67, which was almost statistically similar with the variety BARI Sarisha-6 (10.37 cm) followed by Safol (10.00), and the same number of branch in BARI Sarisha-9 and SS 75 (9.00). The minimum number of branch per plant was found in the variety Tori-7 (7.67), SAU Sarisha-1 (8.00).

In terms of number pod per plant for eight mustard varieties evaluated against aphid under the present trial represented in the Table 8. The maximum number of pod per plant was recorded in the variety Agrani (180.7) followed by BARI Sarisha-6

(174.00). On the other hand, the lowest number of pod per plant (118.7) was recorded in Tori-7.

In terms of length per pod in cm, the maximum length of pod (7.97cm) was recorded in Agrani followed by BARI Sarisha-6 (7.33 cm). On the other hand, the lowest length per pod (5.17 cm) was recorded in Tori-7.

In terms of 1000 seed weight in gm for eight mustard varieties, the maximum weight of 1000 seed (3.10 g) was recorded in Agrani followed by BARI Sarisha-6 (2.86 g) and the minimum weight (2.18 g) of 1000 seeds was recorded in TORI-7, which was statistically identical with 2.70 g recorded in SAU Sarisha-1 and BARI Sarisha-9.

Table 8. Yield attributes of different mustard varieties grown in winter season

Variety	Yield attributes at 62 DAS				
	Height (cm/plant)	Branch (No./plant)	Pod (No./plant)	Pod length (cm/pod)	1000's seed wt. (g)
SAU Sarisha-1	113.0 e	8.00 b	131.70 c	5.40 e	2.70 b
BINA Sarisha-6	117.0 cd	8.33 ab	127.70 cd	5.30 e	2.70 b
Tori-7	103.0 e	7.66 b	118.70 d	5.17 e	2.18 d
BARI Sarisha-9	109.0 de	9.00 ab	131.70 c	5.20 e	2.70 b
BARI Sarisha-6	129.7 b	10.37 a	174.00 a	7.33 b	2.86 ab
Safol	125.0 bc	10.00 ab	158.00 b	6.23 c	2.83 ab
Agrani	148.0 a	10.67 a	180.70 a	7.97 a	3.10 a
SS 75	109.3 de	9.00 ab	136.30 c	5.80 d	2.50 bcd
$LSD_{0.01}$	11.69	2.210	12.09	0.3437	0.3350
CV%	8.43	9.92	3.43	2.34	6.33

In a column means followed by same letter (s) do not differ significantly at 1% by DMRT
*DAS = Days after sowing.

Under considering the above factor it is clearly observed that Agrani is the best in all aspects of yield attributes. Conversely, the variety Tori-7 is the least performer in all aspects of yield attributes and the trend is Agrani > BARI Sarisha-6 > Safol > SS 75 > BINA Sarisha-6 > BARI Sarisha-9 > SAU Sarisha-1 > Tori-7. This result was in agreement with those of Brar and Sandhu (1978), Kabir (1987), Begum (1988) and

Agarwal *et al.* (1996b), who also found yield contributing traits lesser influence of aphid infestation.

4.8. Influence of aphid infestation on yield and yield loss of different mustard varieties

Significant variations were recorded in terms of yield and yield loss among eight mustard varieties represented in Table 9. The highest yield was recorded in the variety Agrani (369.0 gm/plot or 615.50 kg/ha), which was statistically different from other varieties and the lowest yield was found in the variety Tori-7 and this was 224.10 gm/plot or 373.40 kg/ha. As a result, the trend of the yield of eight selected mustard varieties is Agrani > BARI Sarisha-6 > Safol > SS 75 > BINA Sarisha-6 > BARI Sarisha-9 > SAU Sarisha-1 > Tori-7.

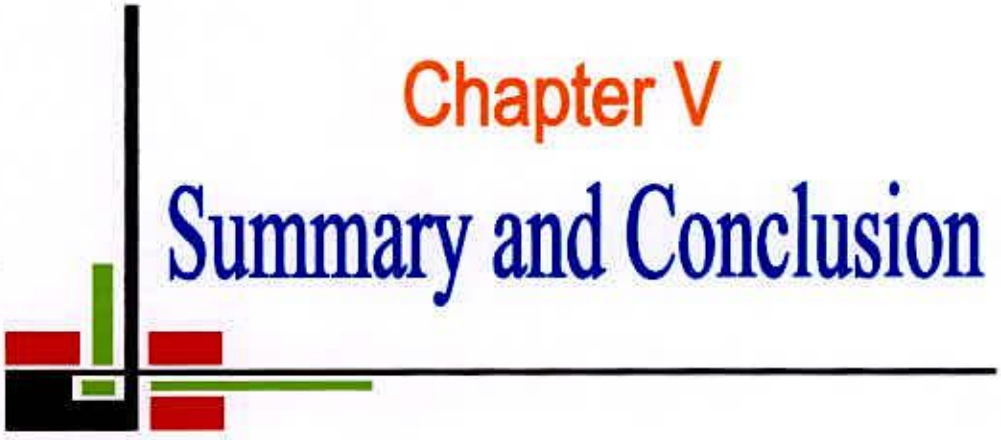
Considering the yield loss caused by aphid infestation among eight mustard varieties, the maximum yield loss (71.50%) was calculated in the variety Tori-7, which was statistically identical with SAU Sarisha-1 (70.00%), BARI Sarisha-9 (69.70%) and BINA Sarisha-6 (66.20%). Conversely, the minimum yield loss (46.20%) was calculated in Agrani, which was statistically similar with BARI Sarisha-6 (51.00%), SS 75 (51.70%) and Safol (53.70%). As a result, the trend of the yield loss caused by aphid infestation among eight mustard varieties is reverse and the trend is Tori-7 > SAU Sarisha-1 > BARI Sarisha-9 > BINA Sarisha-6> SS 75 > Safol > BARI Sarisha 6 > Agrani.

Table 9. Yield and yield loss caused by aphid infestation among different mustard varieties/genotypes grown in winter season

Variety	Grain Yield		Yield loss (%)
	g/plot	kg/ha	
SAU Sarisha-1	228.5 f	380.80 f	70.00 a
BINA Sarisha-6	289.4 d	482.30d	66.20 a
Tori-7	224.1 f	373.40 f	71.50 a
BARI Sarisha-9	257.9 e	429.80 e	69.70 a
BARI Sarisha-6	324.6 b	541.10 b	51.00 b
Safol	318.8 bc	531.30 bc	53.70 b
Agrani	369.3 a	615.50 a	46.20 b
SS 75	296.3 cd	493.80 cd	51.70 b
$LSD_{0.01}$	22.96	38.26	10.80
CV%	3.27%	3.47%	10.17%

Means followed by same letter (s) do not differ significantly at 1% level of significance by DMRT
*DAS = Days after sowing.

From the above findings it is revealed that the highly aphid infested variety Tori-7 produced lowest yield and caused maximum yield loss. Conversely, the least aphid infested variety Agrani produced highest yield and caused minimum yield loss. This result was in agreement with those of Begum (1995) and Mondal *et al.* (1994), who was found that the as the aphid population increased yield loss is high.



Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment on the resistance source(s) among eight mustard varieties against aphid. was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during winter season from November 2007 to February 2008. Abundance and aphid infestation, yield and yield attributes were studied to identify the resistance source(s) among eight locally mustard varieties /genotypes.

Considering the abundance of aphid population, among eight varieties of mustard, Tori-7 performed as the most preferred host followed by SAU Sarisha-1, whereas Agrani, BARI Sarisha-6 and BARI Sarisha-9 performed as least preferred host for mustard aphid in terms of incidence of aphid population by number per plant. And the order of trends in the incidence of aphid population in terms of comparative host preference among eight mustard varieties was Tori-7 > SAU Sarisha-1 > SS 75 > Safol > BINA Sarisha-6 > BARI Sarisha-9 > BARI Sarisha-6 > Agrani.

In respect of incidence of aphid infested branch per plant, the variety Agrani can be identified as least preferred host to mustard aphid. The variety BARI Sarisha-9, BINA Sarisha-6, SS 75, Safol and BARI Sarisha-6 can be identified as moderately preferred; Tori-7 and SAU Sarisha-1 can be identified as most preferred host to aphid infestation. The percent branch infestation was sharply increased with the increase of the plant ages and reached the peak at 62 days after sowing and then gradually decreased. And the order of trend in the mean incidence of aphid infested branch among eight mustard varieties is Tori-7 > SAU Sarisha-1 > BARI Sarisha-9 > BINA Sarisha-6 > SS 75 > Safol > BARI Sarisha-6 > Agrani.

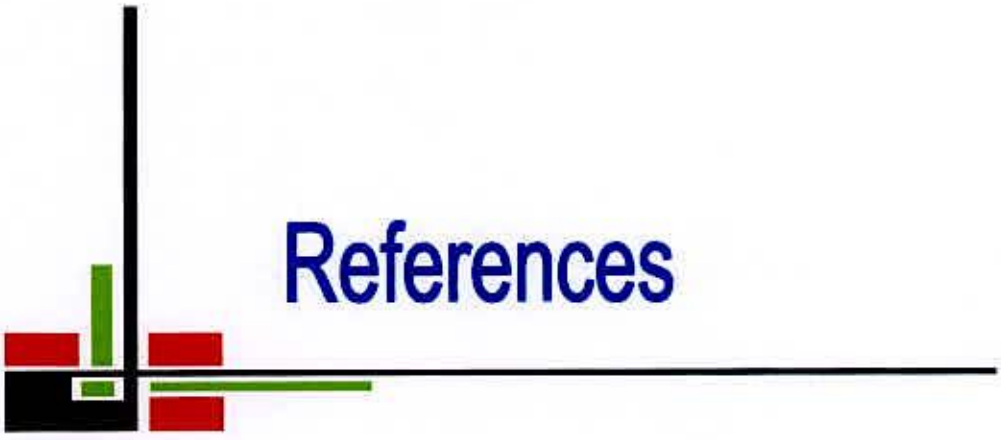
Considering the incidence of aphid infested plants, among the eight varieties of mustard, none was found to be resistant to aphid. The variety Agrani can be regarded moderately resistant to mustard aphid. The variety BARI Sarisha-9, BINA Sarisha-6, SS75, Safol and BARI Sarisha-6 can be regarded as moderately susceptible; Tori-7 and SAU Sarisha-1 can be graded as susceptible to aphid infestation. And the order of trend in the mean incidence of aphid infested plants per plot among eight mustard varieties is Tori-7 > SAU Sarisha-1 > BARI Sarisha-9 > BINA Sarisha-6 > SS 75 > Safol > BARI Sarisha-6 > Agrani.

In respect of incidence of aphid infested inflorescence and pod, the variety Agrani can be identified as least preferred host to mustard aphid. The variety BARI Sarisha-9, BINA Sarisha-6, SS 75, Safol and BARI Sarisha-6 can be identified as moderately preferred; Tori-7 and SAU Sarisha-1 can be identified as most preferred host to aphid infestation. The percent inflorescence infestation was sharply increased with the increase of the plant ages.

Considering the percentage of deformed pod caused by aphid infestation, the highly susceptible variety Tori-7 produced higher percentages of deformed pod due to attack by the higher number aphids. Conversely, Agrani produced lower percentage of deformed pod 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, Agrani was the best in all aspects of yield attributes. Conversely, the variety Tori-7 is the least performer in all aspects of yield attributes and the trend is Agrani > BARI Sarisha-6 > Safol > SS 75 > BINA Sarisha-6 > BARI Sarisha-9 > SAU Sarisha-1 > Tori-7.

Considering the yield and yield loss caused by aphid infestation, the highly aphid infested mustard variety Tori-7 produced lowest yield and caused maximum yield loss. Conversely, the least aphid infested variety Agrani produced highest yield and caused minimum yield loss.



References

REERENCES

CHAPTER VI

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

Agarwal, N. Rohilla, H.R., Singh, H. and Kumar, R. (1996b). Influence on crop morpho-phenological and metrological parameters on the field infestation of mustard aphid, *Lipaphis erysimi* (Kalt.) in *Brassica* genotypes. *Environ. Ecol.*, **14**(II): 268-272.

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

Ahuja, D. B. (1990). Population dynamics of mustard aphid. *Lipaphis erysimi* (Kalt.) on Indian mustard, *Brassica juncea* (sub sp. *juncea*). *Indian J. Plant Prot.* 18(II): 233-23.

Alam, M. Z., Ahmed, A. and Siddique, A. (1964). Control of winter aphids in East Pakistan. A Review of Research Division of Entomology, 1947-64. Agric. Inform. Serv., 3 R. K. Mission Road, Dhaka – 3, pp. 256-259.

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

Anonymous, (1995). Assessment of losses due to aphid infestation at different growth of mustard. Ann. Rep.1994-95, Bangladesh Agric. Res. Inst., Regional Agric Res. Station., Jessore, 120p.

Anonymous. (1996). Evaluation of mustard mutants/varieties for resistance to mustard aphid. Annual Report. Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. 206pp.

Arora, S. K., Saini, M. L., Sandhu, R.S. and. Mahendera, A. S. (1969). Effect of insecticide on yield and quality of Indian mustard (*B. juncea*). *Indian J. Agril. Sci.* 39(v): 444-447.

Atwal, A .S., Chaudhary, J. P and Ramajan, M. (1976). Pests 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 *Lipaphis erysimi* (Kalt.) in India. *In*: A literature study proceeding of with international Rapeseed conference held at Paris from 17-19 May, 1983.

Bakhetia,D.R.C.(1979).New dimension in pest control . Paper presented in Training-cum-discussion Seminar on 'Pest and Disease management in Pulses'at PAU ,Ludhiana from Nov.11-18,1980. pp.14-17.

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

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

BARC.(1999). Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC), Farmgate, New Airport Road, Dhaka-1215.196p.

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 (II): 132.

BBS (2008). Statistical Pocket Book of Bangladesh-07. Bureau of Statistics (BBS), Ministry of Planning, Government of the People's Republic of Bangladesh. 690p.

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

Begum, S. (1994). Assessment of losses due to aphid infestation at different crop growth stages at Joydebpur. Annual Research Report (1993-94). 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 1994-95. Entomol. Div., BARI, Joydebpur , Gazipur. pp.33-34

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

Bhat, G. N., Wani, A. R., Ansari, I. A. (2004). Screening of mustard *Brassica campestris* L. varieties against mustard aphid, *Lipaphis erysimi* (Kalt.) (Homoptera: Aphididae). *Shashpa*, **11** (i): 79-81.

Bishon, O. P., Singh, H. and Singh, R. (1992). Incidence and multiplication of mustard aphid *Lipaphis erysimi* (Kalt.) in relation to metrological variables. *Indian. J. Agric. Sci.* **62** (i): 710-712.

Biswas, G. C. and Das, G. P. (2000). Population dynamics of the mustard aphid, *Lipaphis erysimi* (Kalt.) (Homptera :Aphididae). *Bangladesh J. Ent.* **10**(i - II):15-22.

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

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

Dixon, A. F. G. 1987. Parthenogenetic reproduction and rate of increase in aphid pp. 269 – 287. In: Minks, A. K. and P. H arrewijn (eds). Aphids their biology, natural enemies and control. Elsevier, Amsterdam.

Dixon, A. F. G. and Wellings, P. W. (1982). Seasonality and reproduction in aphids. *Int. J. Inv. Reprod.* 5: 83 – 89.

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

Gami, J.M., Bapodra, J. G. and Rathod, R. (2002). Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) in relation to weather parameters. *Indian J. plant . Prot.* **30** (ii): 202-204.

Ghosh, M. R and Chaudhuri, D. N. R. (1989). Biology of *Lipaphis erysimi* (Kalt.). *Bull. Ent.* **30**(i): 7 – 12.

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

Goel, S. C. and Singh, B. (1994). The intrinsic rate of natural increase and the life expectancy of *Lipaphis erysimi* (Kalt.) on mustard in India. *Insect Sci. Appl.* **15** (iii): 287 – 291.

Hill, D.S. (1983). Agricultural Insect Pests of Tropics and Their Control. Cambridge, University press, London 746 p.

Haider, Hasan, M., F. Ahmed, 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 *Brassica* germplasms for their reaction to aphids. *Bangladesh J. Agric.* 9(iv):31-34.

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

Islam, N. (1991). Effect of sowing time on the abundance of mustard aphid, *Lipaphis erysimi* (Kalt.) on the infestation and yield of mustard. Annual Research Report (1990-91) .Entomol. Div., 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, *Lipaphis erysimi* (Kalt.). *Indian J. Ecol.* **15**(ii): 163-167.

Jarvis, J. L. (1970). Relative injury on some cruciferous oilseeds by the turnip aphid *J. Econ. Entomol.* **63** (v):1498-1502.

Kabir, M.H. (1987). Evaluation of some mustard germplasms for their reaction to mustard aphid, *Lipaphis erysimi* (Kalt.). M.S. Thesis, Dept. of Entomol, Bangladesh Agricultural University, Mymensingh. 64p.

Kabir, S. M. H. and Khan, A.H. (1980). The nature of infestation of *Lipaphis erysimi* and its effects on the growth and yield of mustard crop. Proc. of the 4th and 5th Bangladesh Sci. Conf. 8pp.

Kalra, V. K., Singh, H. and Rohilla, H. R. (1987). Influence of various genotypes of *Brassica* on biology of mustard aphid, *Lipaphis erysimi* (Kalt.). *Indian. J. Agric. Sci.* **57** (II): 227-279.

Kawada, K. 1987. Polymorphism and morph determination. Pp. 255-286. In: Minks, A.K. and P. Harrewijn (eds) Aphids, their Biology natural enemies and control. Vol. A. Elsevier, Amsterdam

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

Kher, S., and Rataul, H.S. (1992b). Screening of some *Brassica* species and their strains for resistance to mustard aphid II based on aphid population. *Indian J. Entomol.* 54(II): 217-221.

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

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

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

Kuo. M.H. (1999). Effects of temperature, photoperiod and crowding treatment on a late formation in the turnip aphid, *Lipaphis erysimi* (Kalt.) plant prot. Bull. Tsipei.**41**(v):255-264.

Lal, M. N., Singh, S. S., and Singh, V. P. (1997). Screening of *Brassica* germplasms for resistance against mustard aphid, *Lipaphis erysimi* (Kalt.). *J. Entomo. Research.* **21**(iv): 371-375.

Luckman, W.H. and Metcalf, R.L. (1975). The pest management concept. *In*: Metcalf, R. L. and Luckman, W. H. (eds), *Introduction to Insect Pest Management*. John Wiley and Sons, New york. pp3-35.

Malik, R.S. (1988). Comparative aphid tolerance in cultivated species of *Brassica.* New Botanist. **165**(ii - iii):113-116.

Malviya, J.K., and Lal, M.N. (2000). Screening of *Brassica* germplasm against mustard aphid, *Lipaphis erysimi* (Kalt.). *Ann Plant Protection Sciences.* 8(ii): 150-153.

Martin. J. H. (1983). The identification of common aphid pests of tropical agriculture. *Tropical pest management.* 5-411 pp.

Mondal, N., Alam, M.S., Hasan, F. and Das, D.C. (1992). Effect on food on larval development period of *Lipaphis erysimi* (Kalt.) and *Aphis cricola. Bangladesh J. Zool.* **20** (ii):297-300.

Mukhopadhyay, D. and Ghosh, M.R. (1979). Effect of phased application of formation and methyldemefen on the incidence of *Lipaphis erysimi* (Kalt.) and the yield of rape seed. *Indian J. Agril. Sci.* **94** (ii):898-900.

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

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

Pandey K.P., Kumar, A. and. Tripathi, C.P.M. (1986). Population ecology of *Lipaphis erysimi* (Kalt.) on *Brassica campestris*. *Bull. Inst. Zool. Academia Sinica.* **25** (ii): 125-228.

Phadke ,K.G.(1982).Life table and growth studies on *L. erysimi* in relation to *brassica* varieties .*Indian J.Ent* .44:136-144.

Prasad,S.K and.Phadke,K.G. (1987). Identification of *Brassica* genotypes least susceptible to mustard aphid , *L .erysimi* (Kalt.) *J. Aphidiology* .1(i - ii) : 93-97.

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

Prasad, S.k. 1983. Varietal Susceptiblity of rapeseed and mustard cultivars to the aphid *L.erysimi* (kalt.) *Indian J. Ent* . 45(iv): 501-503.

Prasad, S. K. (2003). Screening of rapeseed and mustard against mustard aphid, *Lipaphis erysimi* (Kaltenba). *Ann. Agric. Res.* **22**(i): 120-122.

Purina., D., Dutta, S. K. and Das, P. (2002). Influence of metrological factors on the infestation of *Aphid craccivora* Koch, in green gram varieties. *J. Agric. Sci. Soc. North East India.* **15**(i):82-85.

Rai, H. S., Tiwari, R.C., and Shrivastava, R. N. (1995). Screening of toria, yellow sarson and rai entries for tolerance/resistance against mustard aphid *Lipaphis erysimi* (Kalt.). *Crop Res. Hisar.* **10**(ii): 206-208.

Ram, S., and Gupta, M. P. (1987). Effect of weather conditions and time of sowing on the incidence of mustard aphid, *Lipaphis erysimi* (Kalt.). Bhartiya Krishi Anusandhana Patrika, **2** (i) 29-34.

Ram, S., Gupta, M. P. and Mauraya, R.P. (1989). Mustard varieties resistant to aphid (*lipaphis. erysimi* (Kalt.) in India. *Tropic. Pest Manage.* **35**(II):150-153.

Rana, J. S., Khohhar, K. S., Harvir, S. and Sucheta. 1993. Influence of abiotic environment on the population dynamics of mustard aphid, (*L. erysimi* Kalt.). *Crop Res.* 6 (i): 116-119.

Rangre, M. A., Baba, Wani, N. A. (2002). Screening of *Brassica campestris* L. cultivars against mustard aphid, *Lipaphis erysimi* (Kalt.) (Homoptera: Aphididae). *Appl. Biol. Res.* 4(i / II): 75-77.

Rashid, M. A., Hossain, M., Rahaman, M., Rahaman, M. H., Rash., M. H., Nahar, M. S., Alam, S. N., Faruk, I., Jasmine, H. S., Alam, S., Bahet, A., Black, L., Wang, J. F., Talesar, N. E., Luther, G., and Miller, S. (2002). Varietal screening of plant for resistance to bacterial wilt, fruit and stem borer, leaf hopper and root knot nematode and tomato resistance to bacterial wilt, virus disease and root knot nematode. IPMCRSP, 8th Annual Report , 2001-2002 pp77-81.

Reza, S.N. and Masum, A. (2000). Influence of environmental factors on aphid incidence of different bean varieties. *Ind . J. Entomol.* P. 442.

Rohilla, H. R., Singh, H., Yadava, T.P., and Singh, H. (1996). Seasonal abundance of aphid pests on rapeseed mustard crops in Haryana. *Ann. Agric. Bio. Res.* **1** (i - II): 75-78.

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

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

Roy, P. (1975). Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) in west Bengal. *Indian J. Ent.* **37** (iii): 318-321.

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

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

Sahira, D. (1982). The effect of different plant parts on development, reproduction and longevity in *Lipaphis erysimi* (Kalt.) (Homoptera, Aphididae). *J. Res. Assam Agril. Univ.* 3 :67-71.

Samdur, M. Y., Gulati, S. C., Rajni, Raman and Manivel, P. (1997). Effect of environmental factors on mustard aphid, *Lipaphis erysimi* (Kalt.) infestation in different germplasm of Indian mustard, *Brassica juncea* (L.) Coss. *Oilseeds Res.* 14(II): 278-28.

Schmutterer, H. (1978). Pest in tropical crops. *In:* Kranz, J., H. Schmutterer and W. Koch (eds.). Diseases, Pests and Weeds in Tropical Crops. John Wiley and sons, Chichester New York- Brisbane-Toronto. pp. 237-541

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

Shahjahan, M. (1994). Field and laboratory evaluation of some *Brassica* germplasms for resistance to aphid. M. S. Thesis, Dept. of Entomol., Bangladesh Agricultural University, Mymensingh. 89pp.

Singh, B., Gupta, S. K.and Kotwal, D.R. (2004). Screening of some *Brassica* species and their strains for resistance to mustard aphid. *Environ. Ecol.* **22** (iп):565-568.

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

Singh, R. N., Das, R., Gangasarum and Singh, R. K. (1982). Differential response of mustard varieties to aphid, *Lipaphis erysimi* (Kalt.). *Indian J. Ent.* **44**(iv):408.

Singh, S. S. and Lal, M. N. (1999). Seasonal incidence of mustard aphid, *Lipaphis erysimi* (Kalt.) on mustard crop. *J. Ent. Res.* **23**(i i):165-167.

Sinha, R. P., Yazdani, S. S and Verma, G.D. (1989). Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) in relation to ecological parameters. *Indian J. Ent.* **51**(iп): 334-339.

Sinha, R.P., Yazdani, S.S. and. Verma, G.D. (1990). Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) (Homoptera: Aphididae) in relation to ecological parameters. *Indian J. Ent.* **52**(iп): 387-392.

Srivastava, A., Singh, H. and Thekur, H. L. (1996). Assessment of avoidable yield loss caused by green peach aphid, *Myzus persicae* (Sulzer) and mustard aphid *Lipaphis erysimi* (Kalt.) in *Brassica. Indian J. plant Protec.* **24**((i - i i):115-116.

Srivastava, A.S and Srivataawz, J. L. (1970). Insecticides for the control of mustard aphids. *Int. Pests Control.***12** (i i):27.

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

Takar, B. L., Deshwal, H., Jat, B.L. (2003). Screening of different varieties/entries of *Brassica juncea* (L.) Czern and Coss to mustard aphid, *Lipaphis erysimi* (Kalt.) infestation *Ann. Biol.* **19**(i i): 209-212

Thakur, S. S., Parmar, S., Kashyap, N. P. (2002). Field screening of *Brassica* cultivars against mustard aphid, *Lipaphis erysimi* (Kalt.) in higher hills of Himachal Prades. *Indian Insect Environ.* **6**(iii): 138.

Tripathi, N. L. M., Sachan, G. C., Verma, S. K. and Pathak, P. K. (1986). Developmental behaviour of *Lipaphis erysimi* (Kaltenback) on different part/stages of *Brassica campestris* var. toria. *Indian J. Entomol.* **48**(iii): 295-300.

Uttam, S.K., Mohan, K. and Tripathi, R.A. (1993). Studies on population dynamics of mustard aphid *Lipaphis erysimi* (Kalt.). *Annal. Pl. Prot. Sci.* **1**(i): 34-37.

Vekaria, M. V. and Patel ,G.M. (1998). Studies on number on generations of mustard aphid *Lipaphis erysimi* (Kalt.) under laboratory conditions. Pest Management *Econ. Zool*, **6**(ii): 163-165.

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

Verma, R.K., Neeraja, A., Rajak, S. K. (2005). Screening of *Brassica* lines against mustard aphid, *Lipaphis erysimi* (Kalt.). *J. Oilseeds Res.* 22 (i): 220.