EFFECT OF A SEED TREATING CHEMICAL AND THREE PLANT EXTRACTS ON THE MANAGEMENT OF APHID AND SAWFLY INFESTING MUSTARD IN RELATION TO SOWIMG TIME

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CERTIFICATE

This is to certify that the thesis entitled **“EFFECT OF A SEED TREATING CHEMICAL AND THREE PLANT EXTRACTS ON MANAGEMENT OF APHID AND SAWFLY INFESTING MUSTAED IN RELATION TO SOWING TIME”** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN ENTOMOLOGY** embodies the result of a piece of bona fide research work carried out by MD. TOFAYEL ALAM, Registration No. 08-03205 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any other institutes.

I further certify that any help or sources of information, as have been availed during the course of this investigation have duly been acknowledged.

Dated:December,2009
Place: Dhaka, Bangladesh

Mohammed Sakhawat Hossain
Assistant Professor
Supervisor

Dedicated

to

My Beloved Parents

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EFFECT OF A SEED TREATING CHEMICAL AND THREE PLANT EXTRACTS ON THE MANAGEMENT OF APHID AND SAWFLY INFESTING MUSTARD IN RELATION TO SOWING TIME

ABSTRACT

The experiment was conducted to study the effect of a seed treating chemical and three plant extracts on management of Aphid and Sawfly infesting mustard in relation to sowing time in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November 2008 to March 2009. In these study the environmental factors were evaluated at three time e.g.23 November, 30 November and 06 December, 2008. The experiment comprised of the following treatments; T_1: Confider 70WG @ 3 g/kg seeds; T_2: Zinger extract @ 20 ml/L water at 7 days interval; T_3: Turmeric extract @ 20 ml/L water at 7 days interval; T_4: Neem leaf extract 20 ml/L water at 7 days interval and T_5: Control. Three experiments were laid out in three sowing times. Each experiment was set in a Randomized Complete Block Design (RCBD) with three replications. For sowing on 23 November 2008, the lowest number of aphid and sawfly was recorded from T_4, while the highest number obtain from T_5 treated plots at early, mid and late flowering and fruiting stages. The seed yield per hectare was recorded highest from T_4 (2.34 t/ha), while the lowest from T_5 (2.01 t/ha) treated plots. Sowing on 30 November, 2008 showed the lowest number of aphid and sawfly in T_4, while the highest number from T_5 treated plots at early, mid and late flowering and fruiting stages. The highest yield was obtained from T_4 (2.64 t/ha), while the lowest yield was recorded from T_5 (2.02 t/ha) applied plots. Mustard sown on 06 December, 2008 the lowest number of aphid and sawfly in T_4, while the highest number in T_5 treated plots at early, mid and late flowering and fruiting stages. The highest yield was recorded from T_4 (2.21 t/ha) and the lowest yield from T_5 (1.95 t/ha) applied plots.

CHAPTER I

INTRODUCTION

Mustard (*Brassica campestris* L.) and rapeseed (*Brassica olitorius* L.) belongs to the genus *Brassica* of the family Cruciferae and is one of the leading oilseed crops in Bangladesh as well as in the World. In Bangladesh more than 218.47 thousand metric tons of rape and mustard produced from total 287.55 thousand hectares of cultivable land in the year 2007-2008 (BBS, 2009). Mustard occupied the top of the list in respect of area and production compared to other oilseed crops that are grown in Bangladesh. It is mainly a self-pollinating crop, although on an average 7.5 to 30% out-crossing does occur under natural field conditions (Abraham, 1994; Rakow and Woods, 1987). Oilseed crops play a vital role in human nutrition. It is used as a condiment, salad, green manure and fodder crop, and as a leaf and stem vegetable in the various mustard growing countries of the World. In Bangladesh, sources of edible oils are rapeseed-mustard, sesame, groundnut, soybean, niger, linseed, sunflower and safflower. But rapeseed-mustard are the important oilseed crops of the world after soybean and palm (FAO, 2004).

The Oliferous oil is not only the rich source of energy (about 9 Kcal/g) but also the source of rich fat soluble vitamins A, D, E and K. The National Nutrition Council (NNC) of Bangladesh Recommended Dietary Allowance (RDA) per capita per day as 6g of oil for a diet with 2700 Kcal. On RDA basis, the edible oil need for 150 millions people is 0.39 million tons equivalent to 0.82 million tons of oilseed (NNC, 1984). Rapeseed oil is widely used as cooking oil and medicinal ingredient and supplies fat in our daily diet. Domestic production of edible oil almost entirely comes from rapeseed and mustard cultivation occupying only about 2% area of total cultivation area in Bangladesh (BBS, 2002). The annual oil seed production of 0.41 million tons of which the share of rapeseed-mustard was 0.21 million tons, which comes about 52% of the total edible oil seed production (BBS, 2009).

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

There are many insect pests of mustard crop like mustard aphid (*Lipaphis erysimi* Kalt.), sawfly (*Athalia lugens* Kiug), etc. Mustard aphid is the most serious and destructive pest and limiting factors for successful cultivation of mustard in South Asia (Bakhetia, 1983 and Zaman, 1990). The rate of reproduction varies from 5-9 young in a single day by a single female and the total number of young produced by the female varies from 76-188 (Nair, 1986). Both the nymph and adult of the aphid suck sap from leaves, stems, inflorescences and pods, as a result the plant show stunted growth, flowers wither and pod formation is hindered (Atwal and Dhaliwal, 1997; Begum, 1995 and Butane and Jotwanil, 1984). Every effort is therefore being made to raise yield of the crop by adopting modern agricultural practices. The ecological approach to pest management suggests the use of botanical pesticide and some chemical pesticide only and where necessary. It may become therefore, a new and economically &environment friendly approach(s) to insect pest control be undertaken by studying these pest population fluctuation in relation to agro-cofactors. Such study will provide an opportunity to face the pest challenge by manipulating the ecological parameters like the adjustment of planting or harvesting time.

Conceiving the above problems in mind, the present research work has been undertaken to achieve the following objectives:

i. to find out the population incidence of aphid and sawfly in relation to climatic factors,

ii. to evaluate the effect of a seed treating chemical and botanicals on aphid and sawfly infestation and

iii. to find out the suitable botanicals for the management of mustard aphid and sawfly.

CHAPTER II

REVIEW OF LITERATURE

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

2.1 Management of insect pest through environmental factors

Jandial and Kumar (2007) carried out an experiment on the seasonal incidence of mustard aphid (*Lipaphis erysimi* Kalt) on Indian mustard crop at Meerut, Uttar Pradesh, India, during 2002-03 and 2003-04 to determine the effect of temperature and relative humidity on the population buildup of *L. erysimi* on mustard plants. Studies revealed that the incidence of mustard aphid started in the last week of December during both the years and reached its peak in second week of February with 384.15/10 cm terminal shoot during 2002-03 and

424.45/10 cm terminal shoot in first week of February during 2003-04. Studies indicated that mustard aphid incidence was higher when maximum and minimum temperature ranged between 20-27^{0}C and 5-10^{0}C, respectively, and relative humidity during morning and evening hours ranged from 72 to 90% and 53 to 61%, respectively. Positive and non-significant correlation existed between maximum temperature and aphid population during both the years while negative and non-significant correlation observed with minimum temperature, morning and evening relative humidity.

Bhattacharya *et al.* (2007) observed that pest infestation in crops was highly influenced by agro-meteorological parameters. Weather based early warning of pest infestation in being practiced using statistical and dynamic simulation models on point scale. Satellite based inputs and epidemiological models can extend the application to areas with irregular and non-existing ground Administration TIROS TOVS near surface air temperature at 1430 h LAT over India for modeling onset, build-up and peak aphid (*L. erysimi*) infestation on Indian Mustard (*B. juncea*) crop over Bharatpur and Kalyani, falling in semiarid and sub-humid regions, respectively. The daily cumulative TOVS air temperature from 1 October 2001 showed high correlation (R2: 0, 99) with observed datasets. Exponential relationships were found to be the best empirical fit between TOVS cumulative air temperature and crop age at aphid onset (R_2: 0.7-0.99) and peak infestation (R_2: 0, 91-0.95) for two stations representing semi-arid (Bharapur) and sub-humid (Kalyani) agroclimatic conditions. Second order polynomial fits were found (R2: 0.810.85) at both the stations between peak aphid count at peak. Estimates of intermediate linear aphid build-up to peak, computed using location-specific linear growth rate (LGR) showed a higher standard error (SE) of 20% of mean at Kalyani (0-99), compared to 8% at Bharatpur (4-58). The common prediction models on linear start and peak were developed using TOVS noon time specific humidity (SPH) weighted thermal units and sowing dates. The standard error (SE) of estimated intermediate aphid-build-up became less: 4.5% of observed mean counts for pooled datasets with a common model, irrespective of sowing dates. The correlation between estimates and observations was 71%. The common model will be useful for general application in the absence of availability of local models.

Raj *et al.* (2007) carried out an experiment to determine the relative role of weather variables on mustard aphid (*L. erysimi*) population. Field experiments were conducted in Hisar, Haryana, India, during the rabi seasons of 1996-97 and 1997-98, involving 3 sowing dates, i.e; 5 October, 19 October and 24 November in 1996 and 24 November, 4 December and 16 December in 1997 using 4 Indian mustard cultivars, namely Varuna, Laxmi, RH-30 and BSH-. In early sown Indian mustard, the aphid population had a significant negative correlation with minimum and maximum temperature. Similarly, the morning and evening relative humidity and rainfall showed negative correlation with the aphid population. The division of aphid infestation period into 3 different phases of infestation, it was observed that during the establishment phase, the weather parameters had significant role in governing the aphid population. The temperature, rainfall and sunshine hours were negatively correlated, whereas, the morning and evening relative humidity and wind speed showed positive correlation .During the declining phase, the wind speed along with the temperature had negative relationship with the aphid population build-up.

Dhaliwal *et al.* (2005) conducted an experiment in Ludhiana, Punjab, India from 1988-89 to 1996-97 to evaluate the use of agrometeorological indices for forecasting mustard aphid on Raya (*B. juncea*). A formula for measuring the relationship between weekly aphid population and humid-thermal ratio was provided. The years 1992-93 and 1996-97 were characterized with high infestation of aphid populations ranging from 700 to 1300 aphids/plant. The growing degree days accumulated from 1 December for all the years. These were 287, 329 and 839 for first, peak and last aphid incidences, respectively. A pest weather diagram constructed during the high infestation years showed that low minimum temperature, high morning relative humidity, and reduced solar radiation or sunshine hours favoured aphid incidence.

Jat *et al.* (2006) carried out a field experiment during 2002-03, in Bikaner, Rajasthan, India, to evaluate the correlation between meteorological factors and infestation of Indian mustard by sawfly (*Athalia lugens*), painted bug (*Bagrada cruciferarum*) and aphid (*L. erysimi*). Sawfly infestation was observed from the first week after sowing up to the 4^{th} week during rabi 2002-03. Sawfly population peaked (6 grubs per 5 plants) during the 2nd week of November, with maximum and minimum temperatures of 32.1 and 16.3^{0}c and relative humidity of 60% in the morning and 23% in the evening. Similarly, painted bug infestation started at the time of germination (1st to 4th week), which increased gradually and peaked (85 bugs per 5 plants) in the 3rd week of November. The effect of weather factors on the population build-up of the painted bug was not significant. Aphid infestation started in the 3rd week of January (48 aphid per 5 plants), which increased gradually and peaked (295 aphids per 5 plants) in the 2nd week of February and disappeared completely after the 2nd week of March. Aphid population was significantly and positively correlated with both morning and evening relative humidity.

Bhat and Bapodra (2004) carried out a field experiment in Junagadh,, Gujarat, India during 1999-2000 to study the population dynamics of mustard sawfly (*A. lugens proxima* on 3 Indian mustard cultivars, namely Varuna, Gujarat mustard-1 (GM-1) and Gujarat mustard-2 (GM-2). Weekly observations on larval population were recorded at 2 weeks after germination till harvest of the crop. The data on the incidence of mustard sawfly on GM-1, GM-2 and Varuna revealed that the infestation of mustard sawfly commenced in the 3rd week after sowing, i.e. in December (51st standard week), with 0.70, 1.10 and 1.40 larvae per plant, respectively. The pest population increased in the last week of December (52nd standard week), reaching a peak level of 1.70, 1.90 and 2.30 larvae on GM-1, GM-2 and Varuna, respectively. However, it decreased (1.50, 1.70 and 1.80 larvae per plant, respectively) during the 5th week after sowing, i.e; first week of January (1st standard week). Thereafter, the population gradually declined to 0, 0.10, 0.20 and 0.40 larva per plant, respectively, during the 7th week after sowing, i.e; 3rd week of January. However, the pest population again increased (1.50, 1.80 and 2.0 larvae per plant) in the 8th week after sowing i.e. last week of January. However, the pest population again increased (1.50, 1.80 and 2.0 larvae per plant) in the 8th week after sowing, i.e; last week of January. The population declined to 0.10, 0.20 and 0.30 larva per plant on GM-1, GM-2 and Varnua, respectively, in the 12th week after sowing. There were, thus, 2 peak periods of the pest population, i.e; during the flowering and pod stages. The population of the pest showed positive and negative correlation, respectively, with evening relative humidity and minimum temperature. Maximum temperature, morning relative humidity and sunshine hours did not show significant effect on the population phenomena.

The study of Gour and Pareek (2003) the seasonal incidence of major insect pests of mustard during the rabi season of 1999-2000 and 2000-2001 under the semi-arid conditions of Rajasthan, India revealed that the mustard sawfly (*A. lugens*) appeared in the fourth week of October, reached its peak (0.4 and 0.6 grub/plant) and continued up to the first week of December during both years. The painted bug (*B. hilaris*) appeared in the fourth week of October, reaching its maximum (1.8 and 1.2 bug/plant) in the third week of November and persisted up to third week of January. The incidence of mustard aphid (*L.*

erysimi) started in the third week of November reaching to its peak (8.0 and 9.5 aphid/plant) in the second week of January and disappeared in the third week of February during both the years. No significant correlation was observed between mustard sawfly and painted bug population and any abiotic factors except that evening relative humidity showed positive correlation with mustard sawfly population. In case of mustard aphid population, negative correlation was observed with maximum and minimum temperature and positive correlation was observed with morning relative humidity.

Ansari and Shazia (2004) carried out a field experiment in Aligarh, Uttar Pradesh, India, during the 2000/01 rabi season to determine the resistance of 24 rapeseed and mustard cultivars to mustard sawfly, *A. proxima*. The leaves of all cultivars were either moderately of heavily damaged by *A. proxima* larvae. The incidence of *A. proxima* damage was significantly more at early stages of crop growth than later. Maximum damage was observed 50-60 days after sowing on most cultivars then substantially increased up to 80 days after sowing. The maximum damage reached 73.20%. All the cultivars were classified as moderately susceptible (40-49%), susceptible (50-59%) and highly susceptible (60% and above). Comparative data on the correlation between *A. proxima* incidence and temperature and humidity are also tabulated.

Dhaliwal and Hundal (2004) conducted a field experiment in Punjab, India during the rabi seasons of 1999-2000 and 2000-01 to evaluate the use of weather variables in forecasting *L. erysimi* infestation on Indian mustard cv.

PBR-91. The crop was sown on different dates: 5 October, early; 30 October, normal; and 25 November, late. Aphid incidence increased with delay in sowing. The optimum date of sowing was during the first week of October (early sowing), followed by 30 October and 25 November. The weather variables evaluated included maximum and minimum temperature, morning and evening relative humidity, rainfall, solar radiation, sunshine hours, wind speed, and cloudy and foggy conditions. The prediction function using stepwise regression analysis showed a 74% variation in the aphid infestation index due to meteorological parameters, and 66% variation in plant infestation.

Mishra and Kanwat (2003) studied the population build-up of *L. erysimi* infesting Indian mustard (*B. juncea* cv. Varuna) was studied during 2000-2001 and 2001-2002 in Jobner, Rajasthan, India. *L. erysimi* was most abundant during the last week of January. The peak population in 2001 and 2002 was observed under mean maximum temperatures of 23.1 and 21.4^{0}C, mean minimum temperatures of 1.4 and 3.7^{0}c, and mean relative humidity of 53 and 59%, respectively. The sharp decline in aphid population in the first week of February was attributed to rising temperature and production of a late forms coupled with crop maturity. A negative correlation was observed between aphid population and maximum and minimum temperatures, whereas a significant positive correlation was observed between aphid population and relative humidity.

Reza *et al.* (2004) carried out an experiment in Nadia, West Bengal, India, during the rabi season of 2001/02 to investigate the effect of some abiotic factors on the population fluctuation of mustard aphid, *L. erysimi*. The population built up of mustard aphid was initiated in the 51st week during the end of December with initial intensity of 22.67/plant. The population increased up to 3rd standard week in January at the peak of 318.61 per plant. A rapid decrease in population was subsequently observed with complete elimination by the end of February. The aphid population was positively related with temperature but relative humidity had shown slight response on its intensity and without any significant response of little rainfall. At the time of peak infestation, the maximum and minimum temperature was 27.37 and 14.62 degrees C, respectively. The maximum and minimum relative humidity was 95.28 and 62.28%, respectively. In the 4th and 5th standard weeks, a rainfall of 7.40 and 13.10 mm, respectively, decreased the aphid population from 274.33 to 186.33/plant. None of the ecological parameters alone was responsible for rapid multiplication of the aphid.

Prasad (2003) carried out an experiment with Pusa Kalyani, (*B. rapa*, brown sarson), DYS-3 (*B. rapa*, yellow sarson) and Pusa Bold (*B. juncea*) cultivars of mustard for 12 years, i.e. from 1989-90 to 2000-01 in New Delhi, India to investigate the variability in the population in different years. Some weather factors like maximum and minimum temperatures, relative humidity (morning) and relative humidity (afternoon), and rainfall were also recorded to determine their impact on the pest population. The aphid was first noticed on the inflorescence shoot as early as the 51^{st} week during 1996-97 and as late as the 5^{th} week during 1998-99. At the initial stage, the number of aphids/plant was between 1 to 61. Thereafter, the number started increasing and reached peak level. The number of aphids at peak level and the time of reaching peak also differed in different years. The peak was reached earliest (6^{th} standard week) in 1990-91 and in 9^{th} standard week in 2000-2001. The number of aphids at peak was maximum (2350/plant) in 1992-93 and minimum (60 aphids/plant) during 1998-99 crop season. The aphids were on the plants for the shortest period of 5 weeks during 1999-2000 and for the longest period of 13 weeks during 1996-1997.

Sharma *et al*. (2002) conducted field trials during 2000-01 in Rajasthan (Bharatpur and Sriganagar), West Bengal (Mohanpur and Berhampur), Uttar Pradesh (Pantnagar) and Delhi, India to evaluate the effects of weather conditions on the incidence of *L. erysimi* on Indian mustard. The treatments consisted of 2 Indian mustard cultivars (Varuna and Local) and 10 sowing dates (weekly intervals, from 1 October to 3 December). Aphid appearance on traps and on inflorescences of Indian mustard was influenced by maximum temperatures of 20-29^0C, especially when the maximum temperature was 22-25^0C. Aphid appearance was also influenced by maximum relative humidity of <95% and mean relative humidity of <75%. Long hours of wetness and minimum temperature of $<5^0$ also favoured aphid infestation.

Gami *et al.* (2002) conducted an experiment in Junagadh, Gujarat, India, during the 1998/99 rabi season with Indian mustard cultivars Varuna, Gujarat Mustard-1 (GM-1), and Gujarat Mustard-2 (GM-2) to determine the population dynamics of mustard aphid, *L. erysimi*, in relation to weather parameters, i.e. temperature, rain, humidity, radiation, and atmospheric pressure. The incidence of mustard aphid on mustard crop commenced from fourth week after sowing, i.e. the last week of November with population levels of 0.05, 0.50, and 0.40 aphid index per plant on Varuna, GM-1, and GM-2, respectively. In addition, the aphid populations gradually increased and reached peak levels of 4.60, 4.55, and 4.50 aphid index per plant, respectively, during the twelfth week after sowing (third week of January). On the other hand, the index slowly declined to 3.40, 3.35, and 3.50 per plant on Varuna, GM-1, and GM-2, respectively, in the fifteenth week after sowing (second week of February). The pest was active from November to February and the population ranged between 0.40 and 4.60 aphid index per plant on all 3 mustard cultivars. Correlation analysis showed a negative correlation of aphid population with maximum and minimum temperatures, while the morning relative humidity and mean bright sunshine hours were not significant. The afternoon relative humidity showed significant positive correlation with the aphid population, whereas the correlation with wind velocity was not significant.

Deepak *et al.* (2002) evaluated the population dynamics and economic status of mustard aphid, *L. erysimi* based on population density on Indian mustard cv.

Pusa in an experiment in Madhya Pradesh, India, during 1999-2000. Aphid population appeared in the 2nd week of December with its initial intensity of 3 aphid/ plant during 1999-2000. The peak population was during the last week of December when the maximum temperature was 24.1^{0}C, minimum temperature was 9.0^{0}C, relative humidity was 94% in the morning and 33% in the evening, wind velocity was 2.1 kmph and there was no rainfall. The aphid population registered a negative correlation with maximum temperature and temperature difference (maximum-minimum temperature).

Ansari and Naqshband (2002) studied during the rabi season of 2000-2001 in Uttar Pradesh, India, to determine the daily rhythm of mustard sawfly (*A. proxima*) on Indian mustard cv. Pusa Bold. Larval counting was done from the seedling stage to the disappearance of larvae from the field. At 30 to 90 days after sowing, the number of larvae was more on plants (1.3-2.1 larvae per plant) during the evenings than the mornings (0.8 to 1.7 per plant). The number of larvae was higher at the seedling stage than that at the flowering and pod formation stages. The total effect of temperature and humidity is almost inhibitory, deterring the appearance of larvae on plant for feeding.

Panda *et al*. (2000) observed in field studies conducted in Raipur, Madhya Pradesh, India during the 1998-99 winter season to observe the intensity and population fluctuation of *L. erysimi* on *B. juncea* (cv. Pusa) in relation to the prevailing abiotic and biotic factors. The aphid species infested the crop from the 52nd to the 14th standard week (SW) with its peak (302.10 aphids per plant) during 7th SW in 70-day-old crops. The minimum temperature between 7.1 and 15.1 degrees C, maximum temperature between 24.9 and 29 degrees C and mean relative humidity between 61 and 65.5% were found to be congenial for the the proper development of aphid population. The natural enemies like *Menochilus sexmaculatus*, *Coccinella repanda, C. septempunctata* and *Diaeretiella rapae* influenced the aphid population during their activity period from January to February.

Biswas and Das (2000) described that the population dynamics of the mustard aphid, *L. erysimi* on fifteen genotypes of mustard (*B. juncea*, *B. campestris* and *B. napus*) in relation to the prevailing weather factors was studied at the Oilseed Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh, during 1997 and 1998 crop seasons. The first aphid infestation on mustard was noticed in the first week of January in 1997 while in 1998, it was noticed in the third week of January. The aphid population build-up was noticed during January-February, reaching the peak on the 8th February in both 1997 (98.26 aphids per plant) and 1998 (76.22 aphid per plant). Among the fifteen genotypes, Nap-8901 suffered the highest aphid infestation (45.87 aphids per plant) while the lowest aphid infestation (21.18 aphids per plant) was recorded from BC-1592. The ambient sunshine (5.76 to 8.60 h) and the maximum temperature (23.66^{0}C to 25.37^{0}C) during January-February appeared to be the conducive factors for aphid multiplication. Relative humidity (RH) ranging from 62.00 to 74.28% during January-

February was congenial for aphid population build up-while the activity of aphids ceased at 52.43% RH and below.

Yadav *et al.* (2000) reported that the effect of simulated rains of 0, 2, 4, 6, 10 and 15mm done by knapsack sprayer at 0, 2, 4, 8, 12, 24, 48 and 72 h after oxdemeton-methy 10.025% spray on its persistent toxicity to *L. erysimi* (Kalt.) infesting 'RH 30' mustard, *B. juncea* (L.) Czern and Coss crop was studied during 1992-93 and 1993-94 in Haryana. Ten apterous adult aphids were released per potted mustard plant leaf at 0, 1, 3, 5, 7, 10 and 15 days after insecticidal spray followed by simulated rain and later enclosed in a cage. Aphid mortality was recorded 24 h after each release. The aphid mortality decreased with increasing rain level. The persistent toxicity of oxydemeton-methy1 in rain control (no rain but insecticidal spray) was 900 as against 698, 624, 632, 599 and 414 in sets receiving 2, 4, 6, 10 and 15 mm rain, respectively, during 1992-93. During 1993-94 persistent toxicities were 805 in rain control and 610, 619, 593, 590 and 424 in different rain levels. Rain occurring upto 12 h after oxydemeton-methyl spray brought much reduction in persistent toxicity as compared to those occurring 24, 48 and 72 h after the spray. If rain of 15 mm occurs 48 h after oxydemeton-methyl spray than there is no need for its reapplication.

2.2 Effect of chemicals on insect pest management

A field experiment was conducted in Karnataka, India, during 1998-99 and 1999-2000 by Mallapur *et al*. (2001) to evaluate the efficacy of the premix, Match [difenzoquat] + profenofos (at 1 and 1.5 litre/ha), against chilli (*Capsicum annuum*) cv. Dyavanur Deluxe fruit borer *Helicoverpa armigera*. The treatment efficacy was compared with profenofos at 1.5 litre/ha, the standard control (cypermethrin at 0.5 ml/litre) and the recommended package (carbaryl at 3.0 g/litre). Two sprays were applied at an interval of 20 days after appearance of pod borers. The highest larval mortality was observed in plots treated with cypermethrin, followed by Match + profenofos. Fruits whiten was also low in cypermethrin treated plots followed by the premix. The highest yield was obtained by cypermethrin followed by the premix at 1.5 litre/ha.

Kumar *et al*. (2001) conducted the bio-efficacy of triazophos (350 or 700 g/ha), acephate (1000 or 1500 g/ha), cypermethrin (150 and 300 g/ha) and imidacloprid (50 or 70 g/ha) against the major pest complex (aphids, *Myzus persicae*, thrips, *Scirtothrips dorsalis*, gram pod borer, *Helicoverpa armigera*, tobacco caterpillar, *Spodoptera litura*, and sunhemp hairy caterpillar, *Utetheisa pulchella*) of chilli (*Capsicum* spp.) was evaluated in a field experiment conducted in Rajendranagar, Hyderabad, Andhra Pradesh, India during kharif season of 1997-98. Imidacloprid (70 g/ha) was the best treatment in controlling aphids (99.76% reduction). Acephate (1500 g/ha) was the most effective in controlling thrips (87.22% reduction). Cypermethrin (300 g/ha) was generally the most effective insecticides against borers.

Nelson and Natarajan (1994) conducted an experiment in 1990-91 and 1991-92 in Paramakudi, Tamil Nadu, India on fruit borer populations, damage, fruit set percentage and yield of chillies. A regression equation was obtained to relate damage score to yield loss. Yield losses of up to 50% were observed due to fruit borer damage. Even at the lowest population density observed (2/plant), spraying with dimethoate is recommended to reduce yield losses.

Nelson and Natarajan (1994) conducted an experiment during a field trial in 1990-91 in Paramakudi, Tamil Nadu, to evaluate the moult inhibitor diflubenzuron and a nuclear polyhedrosis virus (NPV) and found reduced damage by fruit borers on chillies. In plots treated with diflubenzuron, larval/pupal intermediaries were observed.

In plot experiments conducted by Torner *et al*. (1993) in Spain, the presence of a *S. nigrum* plant at 10, 50, 80 and 110 cm from a *Capsicum annuum* plant caused yield losses of 59, 48, 26 and 9%, respectively. It was concluded that one *S. nigrum* every 2.5 m in the crop row resulted in a *C. annum* yield loss of 34%.

Frank *et al*. (1992) carried out a field experiment at Frederick, Maryland, in 1985-86 to determine effects of weed-interference periods and insects on *C. annuum* cv. Yolo Wonder. Weed interference for approx. 40 and 60 d reduced both fruit number and wt by 10 and 50% respectively. *C. annuum* foliage wt was reduced by 10 and 50% with approx. 20-and 50-d weed-interference periods, respectively. In 1985 and 1986, insect populations were low, with an av. of 10 and 3% of the fruit infested, respectively. Most infested fruit was damaged by European corn borer (*Ostrinia nubilalis*). No differences in insect infestation of fruit as related to time of weed interference periods were noted.

2.3 Effect of botanical extract on insect pest management

Sundarajan (2002) conducted methanol extracts of selected plants namely *Anisomeles malabarica*, *Ocimum canum*, *O. basilicum*, *Euphorbia hirta*, *E. heterophylla*, *Vitex negundo*, *Tagetes indica* and *Parthenium hysterophorus* were screened for their insecticidal activity against the fourth instar larvae of *H. armigera* by applying dipping method of the leaf extracts at various concentrations (0.25, 0.5, 1.0, 1.5 and 20) on young tomato leaves. The larval mortality of more than 50% has been recorded for all the plant extracts in 2 per cent test concentration (48 h) except *E. heterophylla* which recorded 47.3 per cent mortality in 2 per cent concentration. Among the plant extracts tested *V. negundo* is found to show higher rate of mortality (82.5%) at 2 per cent concentration.

Kulat *et al.* (2001) conducted an experiment on extracts of some indigenous plant materials, which are claimed important as pest control like seed kernels of neem, *Azadiracta indica*, *Pongamia glabra* [*P. pinnata*], leaves of tobacco, *Nicotiana tabacum* and indiara, a neem based herbal product, against *H. armigera* on chickpea cv. I.C.C.V.5 for its management in Rabi seasons of 1993-96 at College of Agriculture, Nagpur, Maharashtra, India. The results revealed that the crop treated with the leaf extract of *N. tabacum* and seed extract of *P. glabra* (5%) and indiara (1%) and neem seed kernel extract (5%) exhibited low level of population built up compared to control.

Sundararajan (2001) carried out toxicological studies to evalute the effect of leaf methanolic extracts of 5 indigenous plant materials namely, *Abutilon indicum, Achyranthes aspera, Ailanthus excelsa, Alstonia venenata and Azima tetracantha* against *H. armigera*. Larval mortality on tomato leaves treated with *A. tetracantha, A. aspera, A. indicm, A. excelsa and A. venenata* averaged 51, 58, 62, 67 and 73%, respectively.

Ju *et al*. (2000) conducted six desert plants chosen to study their toxicity and effects on the growth and metamorphosis of the insect pest *H. armigera*. An artificial diet containing 5% aqueous extracts of *Cynanchum auriculatum* or *Peganum harmala* var. multisecta showed strong toxicity to the larvae and caused mortality of 100% and 55%, respectively. These two extracts at the same dosage also significantly affected metamorphosis of the insect. An artificial diet containing 1% aqueous extracts of *C. auriculatum* or 5% aqueous extracts of *P. harmala* resulted in mortality of 85% and 55%, respectively, and a zero emergence rate. The other plant species tested were *Euphorbia helioscopia*, *Sophora alopecuroides, P. nigellastrum and Thermopsis lanceolata*. The extracts of these species caused either much lower mortality of *H. armigera* or zero mortality (*E. helioscopia*).

Sundarajan and Kumuthakalavalli (2000) conducted Petroleum ether extracts of the leaves of *Gnidia glauca* Gilg., *Leucas aspera* Link., and *Toddalia asiatica*

Lam. tested against sixth instar larvae of *H. armigera* (Hubner.) at 0.2, 0.4, 0.6, 0.8 and 1.0% by applying to bhendi (okra) slices. After 24 h, percent mortality, EC50 and EC90 were calculated. Total mortality was recorded in the treatment with 0.8% of the extract of *G. glauca.* Of the three leaf extracts used, *G. glauca* showed an EC_{50} of 0.31%.

The efficacy of leaf (5 or 10%) and seed kernel (5%) extracts of neem *A. indica* and leaf extract (5 or 10%) of *Ageratum* sp. and a formulated fish product (5%) was tested under laboratory condition against bean aphid, *Aphis craccivora* by Prabal *et al*. (2000). All the treatments showed significantly better nymphal mortality than the control. The maximum aphid mortality (97.50%) was observed at neem seed kernel extract, followed by neem leaf extract at 10% (61.88%).

Lopez *et al.* (1999) studing short-term choice and no-choice feeding used to assess the antifeedant activity of *T. havanensis* fruit extracts (at 5000 ppm) against 5th-instar *H. armigera* larvae. The acetonic extract gave the highest activity and was further fractionated by silica gel column chromatography. Of the 7 fractions isolated, 5 were identified as the limonoids azadirone, trichilinone acetate, 14, 15-deoxyhavanensin-1, 7-diacetate, 14, 15-deoxyhavanensine-3, 7-diacetate and a mixture of havanensin-1, 7-diacetate and havanensin-3, 7-diacetate. Choice and no-choice feeding assays of each fraction at 1000 ppm, showed that the mixture of havanensin-1, 7-diacetate and havanensin-3, 7-diacetate had the highest antifeedant activity against *H.*

armigera larvae. Azadirone and trichilinone acetate were also antifeedants. No antifeedant activity was found in the remaining fractions.

Khorsheduzzaman *et al*. (1998) reported that neem oil @ 30 ml/l of water can provide 41.11% infestation over control by the brinjal shoot and fruit borer. The neem oil provided 49.1% brinjal shoot and fruit borer infestation reduction over control.

Gopal *et al.* (1997) conducted field trials in India during 1989-92 to determine the efficacy of insecticides (endosulfan and diflubenzurun), neem products and nuclear polyhedrosis virus (NPV) alone or in combination for the control of fruit borer, *H. armigera*, infesting tomatoes. Neem seed kernel extract (NSKE) 3% + endosulfan 0.035% + NPV at 250 larval equivalents (LE) ha^{-1} applied 3 times at 45,55 and 65 days after planting gave the highest larval mortality, reduced fruit damage, and resulted highest fruit yield, followed by neem oil 3% + endosulfan 0.035% + NPV at $250LEha^{-1}$, and endosulfan 0.07% gave the highest cost:benefit ratio, followed by NSKE 3% + NPV at 250LE ha^{-1}, AND NSKE 3% + endosulfan 0.035% +NPV at 250 LE ha^{-1}.

Tomato plants (variety UC-97) were cultivated in pots and left to become naturally infested with *Bemisia tabaci* in an open field and were sprayed with various concentrations of plant extract. The high concentration of all the tested extracts exhibited positive response (Diemetry, *et al*., 1996). Saibllon *et al*. (1995) studied the effects of extracts from *Ricinus communis, Melia azadarach*, *A. indica*, and a tobacco derived commercial product against *B. tabaci*. None of the treatments controlled *B. tabaci*, but numbers were reduced on neem treated plants and these plots gave higher yield than others.

Botanical pesticides are becoming popular day by day. It was found that Lepidopteran insect is possible to control by botanical substances. Weekly spray application of the extract of neem seed kernel has been found to be effective against *H. armigera* (Karim, 1994). The leaf extract of neem tested against the leaf caterpillar of brinjal, *Selepa docilis* at 5% concentration had a high antifeedent activity (Jacob and Sheila, 1994).

Pal and Basu (1993) conducteds experiment on high vigour (freshly harvested) wheat cv. Sonalika seeds were mixed with powdered air-dried red chilli (*C. frutescens*) at 0.1-0.5 g/kg seed, turmeric (*Curcuma longa*) at 0.2-1.0 g, or neem (*A. indica*) at 0.2-1.0g. Results of germination tests conducted 7 days after treatment showed that treated and untreated seeds gave 100% germination but total seedling length was greater for treated seeds, especially those treated with neem. After accelerated aging at 98% RH and 40^0C, 56.2% germination of untreated seeds was recorded, whilst germination rates in treated seeds were 15-20% better (70.9-76%), and seeding growth was increased 30-35%. Treated wheat seeds stored for 7 months under ambient conditions produced lower level of aldehyde than untreated seeds.

CHAPTER III

MATERIALS AND METHODS

The study was conducted during the period from November 2008 to March 2009 to evaluate the effect of a seed treating chemical and three plant extracts for the management of Aphid and Sawfly infesting mustard in relation to sowing time. The details of the materials and methods used in this study are presented below:

3.1 Location

The field study was carried out in the experimental farm of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude and an elevation of 8.2 m from sea level.

3.2 Climate

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

3.3 Soil

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

3.4 Test crop and its characteristics

Seeds of BARI SARISA-11 were selected for this study. This variety was developed at the Bangladesh Agricultural Research Institute in the year of 2004. The plant height of this variety is 90-110 cm and life cycle 90-95 days for robi season cultivation.

3.5 Experimental details

Three (03) experiments were conducted to find out the effect of a seed treating chemical and three plant extracts on management of Aphid and Sawfly infestation. For three experiments, there effects were evaluated on the basis of sowing time. Three sowing time such as, sowing at 23 November (early), 30 November (medium) and 06 December (late), 2008 were considered as environmental factors for the experiment.

The experiment comprised of the following treatments:

T_1: Confider 70WG. @ 3 g/kg seeds,

T_2: Zinger extract @ 20 ml/L water at 7 days interval,

T_3: Turmeric extract @ 20 ml/L water at 7 days interval,

T_4: Neem leaf extract 20 ml/L water at 7 days interval and

T_5: Control.

3.6. Collection and preparation of treatment components

3.6.1. Confider

Confider used as a seed treating chemical and collected from local market and the mustard seeds were treated @ 3 g/kg seeds.

3.6.2. Zinger extract

Fresh 1 kg of zinger was collected from Agargaon Bazar, Sher-e-Bangla Nagar, Dhaka. Then it was blended by a blender. The water extraction was made up by juicy zinger and was applied in the field @ 20 ml/l water at 7 days interval.

3.6.3. Turmeric extract

Fresh 1 kg of turmeric was collected from Agargaon Bazar, Sher-e-Bangla Nagar, Dhaka. Then it was blended by a blender. The water extraction was made as juicy turmeric and it was applied in the field @ 20 ml/l water at 7 days interval.

3.6.4. Neem extract

Fresh green neem leaves were collected from Sher-e-Bangla Agricultural University campus. Then the fresh leaves were blended by a blender. The water extract was made and sprayed @ 20 ml/l water. Neem extract was applied in the field at 7 days interval.

3.7. Experimental design and layout

Three experiments were laid out in three sowing times. Each experiment was set in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing all of the treatments. Each experiment consists of total 15 plots of size 2.5 m × 1.5 m for each of 3 replications. All the 5 treatments of the experiment was assigned at random into 5 plots of each block/replication.

3.8. Growing of crops

The experiment plot was opened in the second week of November 2008 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for mustard seed sowing.

3.9. Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of Urea, TSP, MP, Gypsum, Zinc sulphate and borax, respectively were applied (Table 1). The entire amount of TSP, MP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Urea was applied in two equal installments at final land preparation and before flowering after 45 days of seeds sowing. The dose and method of application of fertilizer are shown in Table 1 (Anon., 2005).

Table 1. Dose and method of application of fertilizers in mustard field

Fertilizers	Dose (kg/ha)	Application (%)	
		Basal	1st installment
Urea	300	50	50
TSP	180	100	--
MP	100	100	--
Gypsum	180	100	--
Znic sulphate	07	100	
Borax	15	100	--

3.10. After care

After establishment of seedlings, following intercultural operations were accomplished for better growth and development of the mustard plant. Different stage of seedling are shown in plate 1, 2 and 3.

3.10.1. Irrigation and drainage

Single irrigation was applied before flowering stage. Drained facilities were provided to drain out access rain water if any.

3.10.2. Weeding

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

3.11. Harvesting, threshing and cleaning

The mustard was harvested at maturity and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, and tagged

Plate1. First sowing show early flowering

Plate 2. Second sowing show vegetative growth

Plate 3. Third sowing show seedlings of mustard

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and finally brought to threshing floor. Threshing and cleaning of mustard seeds finally weighed were and converted into per hectare yield

3.12 Monitoring of insect pest

The mustard plants were closely examined at indicates the interval commencing from flowering to pod maturity. Aphids and sawfly per plant was recorded at weekly intervals from the randomly tagged 10 plants in central rows and starting from flowering to pod maturity and converted into per plant. The aphid and sawfly was collected by a needle brush and placed in a Petri dish. The entire period were divided into early, mid and late flowering and fruiting stages and measured the incidence of the attack of aphid and sawfly.

3.13 Yield contributing characters and yield of mustard

Data were recorded on the following yield contributing characters and yield of mustard:

3.13.1. Plant height

The height of plant was recorded in centimeter (cm) at harvest in the experimental plots. Data were recorded as the mean of 10 plants selected at random from the inner rows of each plot after harvest. The height was measured from the ground level to the tip of the growing point of the main branch.

3.13.2. Number of branches per plant

The total number of branches developed from the stem of a plant was counted as the number of branches per plant.

3.13.3. Number of siliqua per plant

The total numbers of siliqua of the randomly selected 10 plants of a plot were recorded and then mean number of siliqua was estimated.

3.13.4. Length of siliqua

Distance between the ends of the peduncle to the starting point of the beak was recorded as siliqua length and was presented in cm.

3.13.5. Number of seeds per siliqua

Ten siliqua from each plant were selected randomly and number of seeds was counted and the average number of seed per siliqua was determined.

3.13.6. Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds and then weighed in gm.

3.13.7 Yield per hectare

Seed weight per plot was measured from the harvested seeds of mustard and then converted into ton per hectare yield.

3.15. Statistical Analysis

The data related to insect pests incidence and different yield contributing characters were statistically analyzed to observe the significant difference among the treatment. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means were determined by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Plate 4. Photograph showing aphid on mustard plant

Plate 5. Photograph showing sawfly on mustard plant

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to determine the effect of a seed treating chemical and three plant extracts on management of Aphid and Sawfly infesting mustard in relation to sowing time. Data on aphid and sawfly incidence and their effect on yield contributing characters and yield were recorded. The results on different parameters have been presented, discussed, and possible interpretations also given under the following sub headings:

4.1 Sowing on 23 November, 2008

Statistically significant variation was recorded in number of aphid and sawfly at early, mid & late flowering stage and yield and yield contributing characters due to different management practices with environmental factors i.e; sowing mustard at 23 November, 2008.

4.1.1 Aphid infestation

In case of aphid (plate no.4) incidence, at early flowering stage, significantly the lowest number of aphid (0.55) was recorded from T_4 (Neem extract) treated plots, which was followed (1.40 and 1.65) by T_2 (Zinger extract) and T_3 (Turmeric extract), and these not significantly different. While significantly the highest number was found from T_5 (7.56) untreated plots .This was followed (2.40) by T_1 (Confider as a seed treating chemical) (Table 2). At mid flowering stage, significantly the lowest number of aphid was obtained from T_4 (1.15), which was followed by T_2 (2.80), again the highest number was recorded from T_5 (9.75) treated plots which was followed by T_1 (4.55). At late flowering stage, the lowest number of aphid was observed from T_4 (1.50) treated plots, which was followed by T_2 (4.15) and T_3 (4.65) applied plot. Again, the highest number was found from T_5 (11.60), which were followed by T_1 (5.70) treated plots. Bhattacharya *et al.* (2007) observed that pest infestation in crops is highly influenced by agro-meteorological parameters. Weather based early warning of pest infestation in being practiced using statistical and dynamic simulation models on point scale.

At early fruiting stage, significantly the lowest number of aphid was recorded from T_4 (1.85) which was not statistically identical with T_2 (3.35), T_3 (3.50) and T_1 (4.10), treated plots but these was significant differ among these. The highest number was obtained from T_5 (8.20) untreated control plot (Table 2). At mid fruiting stage, the lowest number of aphid was recorded from T_4 (2.00), which was followed by T_3 (4.70), T_2 (4.85) and T_1 treated plots (5.25), whereas the highest number was found from T_5 untreated control plot (9.55). Similar statistical relationship was obtained as calculated at early stage. At late fruiting stage, significantly the lowest number of aphid was observed from T_4 treated plots (3.15), which was followed by T_2 (6.20) and T_3 (6.45) treated plots with no significant difference between the late, significantly the highest which infestation was recorded from T_5 control plot (13.20).

In aphid incidence in relation to weather factor (temperature, relative humidity, sunshine and rainfall) indicate that with the increase of temperature and sunshine aphid incidence increased and due to the increase of relative humidity and rainfall the population decline. Similar results were obtained at fruiting stage (Figure 1 and Figure 2).

Kulat *et al.* (2001) reported that the crop treated with the leaf extract of *N. tabacum* and seed extract of *P. glabra* (5%) and indiara (1%) and neem seed kernel extract (5%) exhibited low level of population built up compared to control. The efficacy of leaf (5 or 10%) and seed kernel (5%) extracts of neem and leaf extract (5 or 10%) of *Ageratum* sp. and a formulated fish product (5%) was tested under laboratory condition against bean aphid, *Aphis craccivora* by Prabal *et al*. (2000).All the treatments showed significantly better nympal mortality than the control. The maximum aphid mortality (97.50%) was observed at neem seed kernel extract followed by neem leaf extract at (61.88).

4.1.2 Sawfly infestation

In case of sawfly (plate no.5) incidence, at early flowering stage, no sawfly was found in T_4 (0.00) treated plot which was statistically similar to these of T_2 (0.40) and T_3 (1.25) treated plot. On the other hand, the highest number of sawfly was obtained from T_5 (4.65) untreated plot, which was followed by T_1 (2.15) treated plot these was significantly different At mid flowering stage, no sawfly was obtain in T_4 (0.00) treated plot, which was statistically identical with T_2 (0.15) and T_3 (0.60) treated plot, again the highest number was recorded from T_5 (2.30), which was followed by T_1 (1.00) and these were significantly different from each other. At late flowering stage, no incidence was appeared on T_4 and T_2 treated plot (Table 3). The lowest number of sawfly was obtained from T_3 (0.55) treated plot while the highest number (1.85) recorded from $T_{5,}$ which was followed by T_1 (1.10).

At early fruiting stage, the lowest number of sawfly was observed from T_4 (0.70) plot, which was followed by T_2 (1.40) and T_3 (1.80) plots. On the other hand significantly the highest was recorded from T_5 (5.60), which was followed by T_1 (3.80). At mid fruiting stage, the lowest number of sawfly was recorded from T_4 (0.35) plot, which was statistically similar to these of T_2 (0.85) and T_3 (1.55) plot, whereas significantly the highest number was found from T_5 (5.10) which was followed by T_1 (3.95) plot. At late fruiting stage, no sawfly was recorded from T_4 (0.00) treated plots, which was statistically identical to these of T_2 (0.65) and followed by T_3 (1.35) treated plot. Significantly the highest number was obtained from T_5 (4.70) plot, which was followed by T_1 (3.20) (Table 3). Sawfly incidence in relation to weather factor (temperature, relative humidity, sunshine and rainfall) indicates that with the increased temperature and sunshine sawfly incidence decreased and due to the decreased relative humidity and rainfall it increases. Similar results were obtained at fruiting stage (Figure 3 and Figure 4). Diemetry, *et al*., 1996; Gopal *et al.* (1997) and Saibllon *et al*. (1995) also reported similar results earlier from their experiment. Gopal *et al.* (1997) conducted field trials in India during

1989-92 to determine the efficacy of insecticides (endosulfan and diflubenzurun), neem products and

Table 2. Effect of different treatments on mustard aphid during flowering and fruiting stage of mustard sown on 23 November

Treatments	Number of aphid $plant^{-1}$					
	Flowering stage			Fruiting stage		
	Early	Mid	Late	Early	Mid	Late
T_1	2.40 b	4.55 b	5.70 b	4.10 b	5.25 b	8.65 b
T_2	1.40 c	2.80 d	4.15 b	3.35 b	4.85 b	6.20 c
T_3	1.65 c	3.10 c	4.65 b	3.50 b	4.70 b	6.45 c
T_4	0.55 d	1.15 e	1.50 c	1.85 c	2.00 c	3.15 d
T_5	7.56 a	9.75 a	11.60 a	8.20 a	9.55 a	13.20 a
Significance level	0.01	0.05	0.05	0.01	0.05	0.01
CV(%)	8.51	10.77	5.49	7.32	13.02	5.81

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical) T_2: Zinger extract
T_3: Turmeric extract T_4: Neem extract
T_5: Control

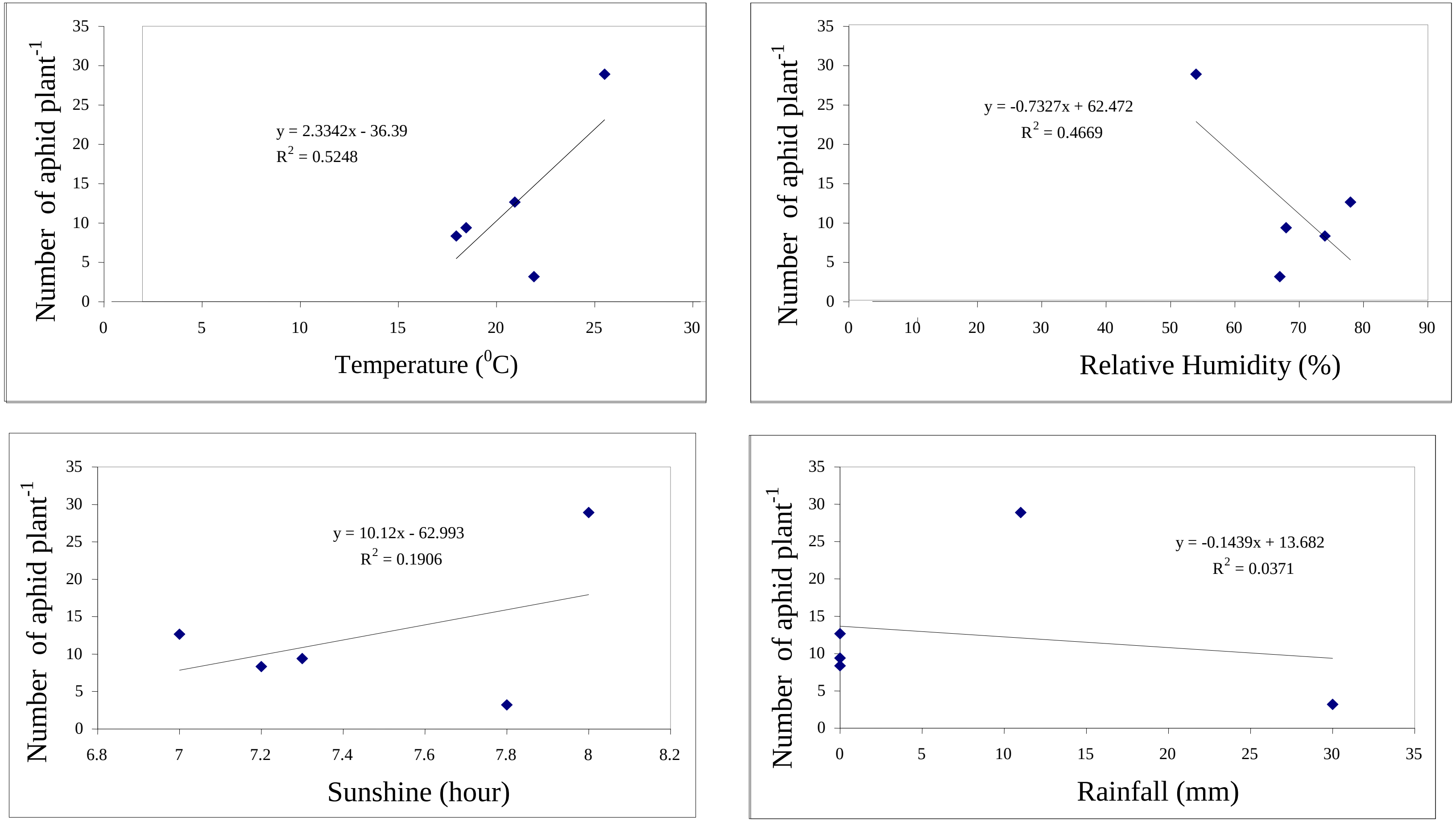

Figure 1. Aphid incidence in relation to weather factor (temperature, relative humidity sunshine and rainfall) at flowering stage

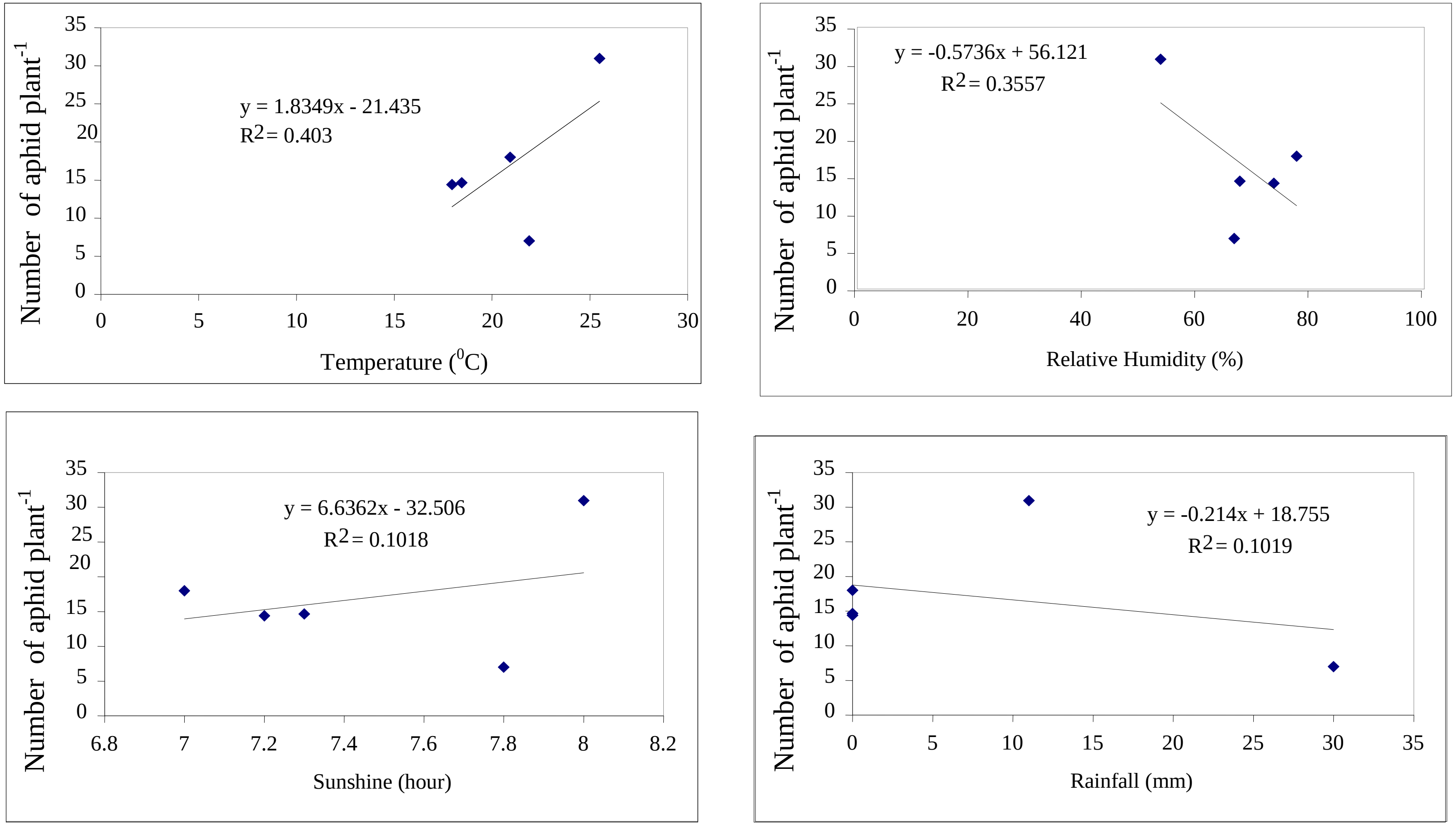

Figure 2. Aphid incidence in relation to weather factor (temperature, relative humidity sunshine and rainfall) at fruiting stage

nuclear polyhedrosis virus (NPV) alone or in combination for the control of fruit borer, *H. armigera*, on tomatoes Neem seed kernel extract (NSKE) 3% + endosulfan 0.035% + NPV at 250 larval equivalents (LE) ha^{-1} applied 3 times at 45,55 and 65 days after planting gave the highest larval mortality, reduced fruit damage, and the highest fruit yield, followed by neem oil 3% + endosulfan 0.035% + NPV at 250LEha^{-1}, and endosulfan 0.07% gave the highest cost:benefit ratio, followed by NSKE 3% + NPV at 250LE ha^{-1}, AND NSKE 3% + endosulfan 0.035% +NPV at 250 LE ha^{-1}.

4.1.3 Yield and yield contributing characters

Considering plant height, significantly the longest plant was found from T_4 (116.40 cm) treated plot which was followed by T_2 (112.90 cm) and T_3 (111.55 cm),and these were statistically similar. On the other hand, significantly the shortest plant was recorded from T_5 (101.80 cm) which was followed by T_1 (108.75 cm) (Table 4). In case of number of branches per plant, the highest number of branches per plant was recorded from T_4 (12.85) treated plot which was statistically identical to these of T_3 (11.00) and T_3 (11.34) treated plot .Again the lowest number of branches per plant of was found from T_5 (10.10) which was statistically similar to these of T_1 (10.45) (Table 4) treated plot. Raj *et al.* (2007) also reported similar findings earlier. Pal and Basu (1993) also reported similar findings from their earlier experiment. Significantly the highest number of siliqua per plant was obtained from T_4 (122.55) treated plot which was numerically followed by T_2 (119.10)

Table 3. Effect of different treatments on sawfly during flowering and fruiting stage of mustard sowing on 23 November

Treatments	Number of sawfly plant^{-1}					
	Flowering stage			Fruiting stage		
	Early	Mid	Late	Early	Mid	Late
T_1	2.15 b	1.00 b	1.10 b	3.80 b	3.95 b	3.20 b
T_2	0.40 d	0.15 c	0.00 d	1.40 c	0.85 d	0.65 d
T_3	1.25 c	0.60 bc	0.55 c	1.80 c	1.55 cd	1.35 c
T_4	0.00 e	0.00 c	0.00 d	0.70 d	0.35 d	0.00 d
T_5	4.65 a	2.30 a	1.85 a	5.60 a	5.10 a	4.70 a
Significance level	0.05	0.01	0.01	0.05	0.01	0.01
CV(%)	7.21	12.15	5.24	10.04	8.92	6.56

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical) T_2: Zinger extract
T_3: Turmeric extract T_4: Neem extract
T_5: Control

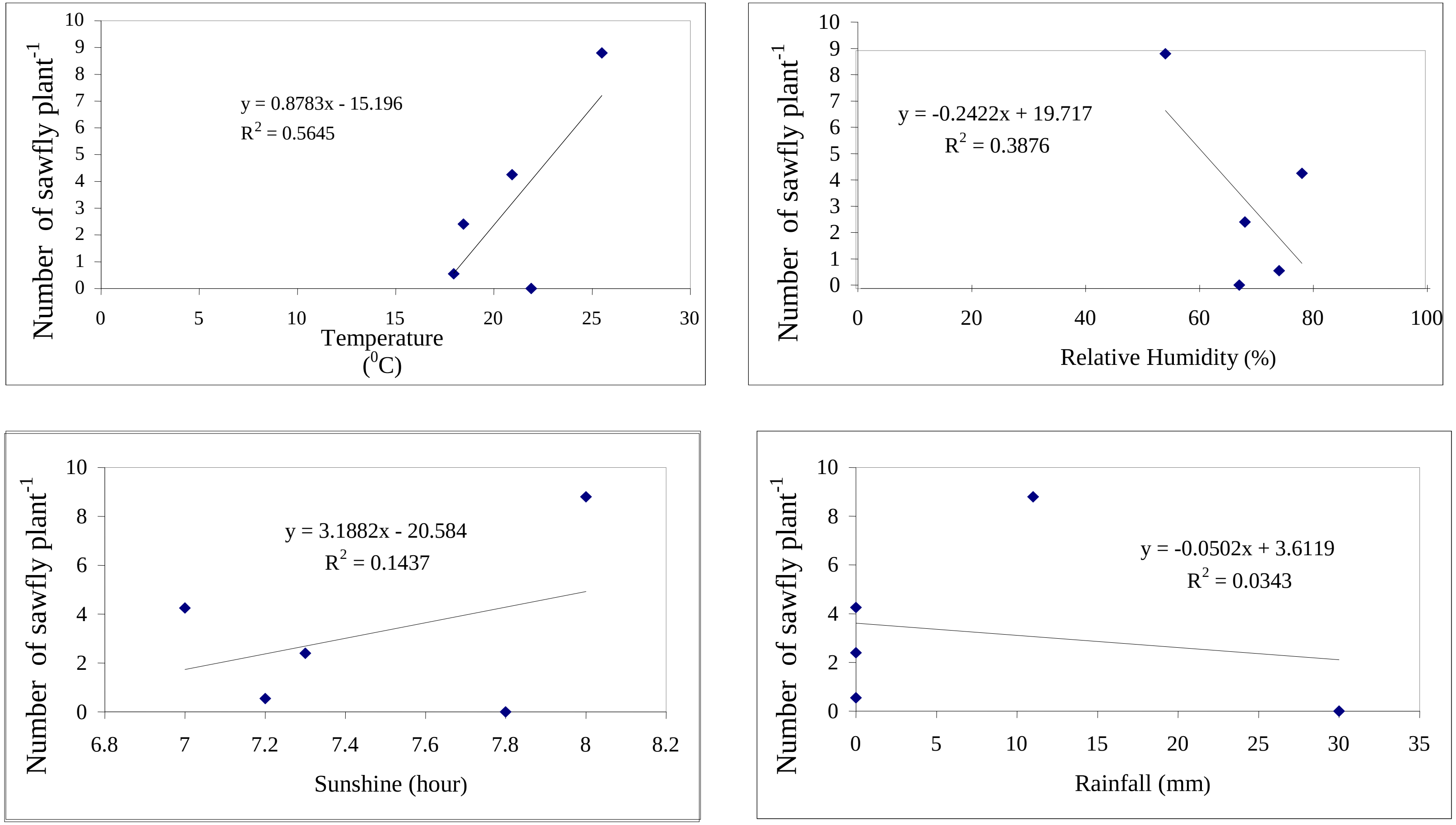

Figure 3. Sawfly incidence in relation to weather factor (temperature, relative humidity sunshine and rainfall) at flowering stage.

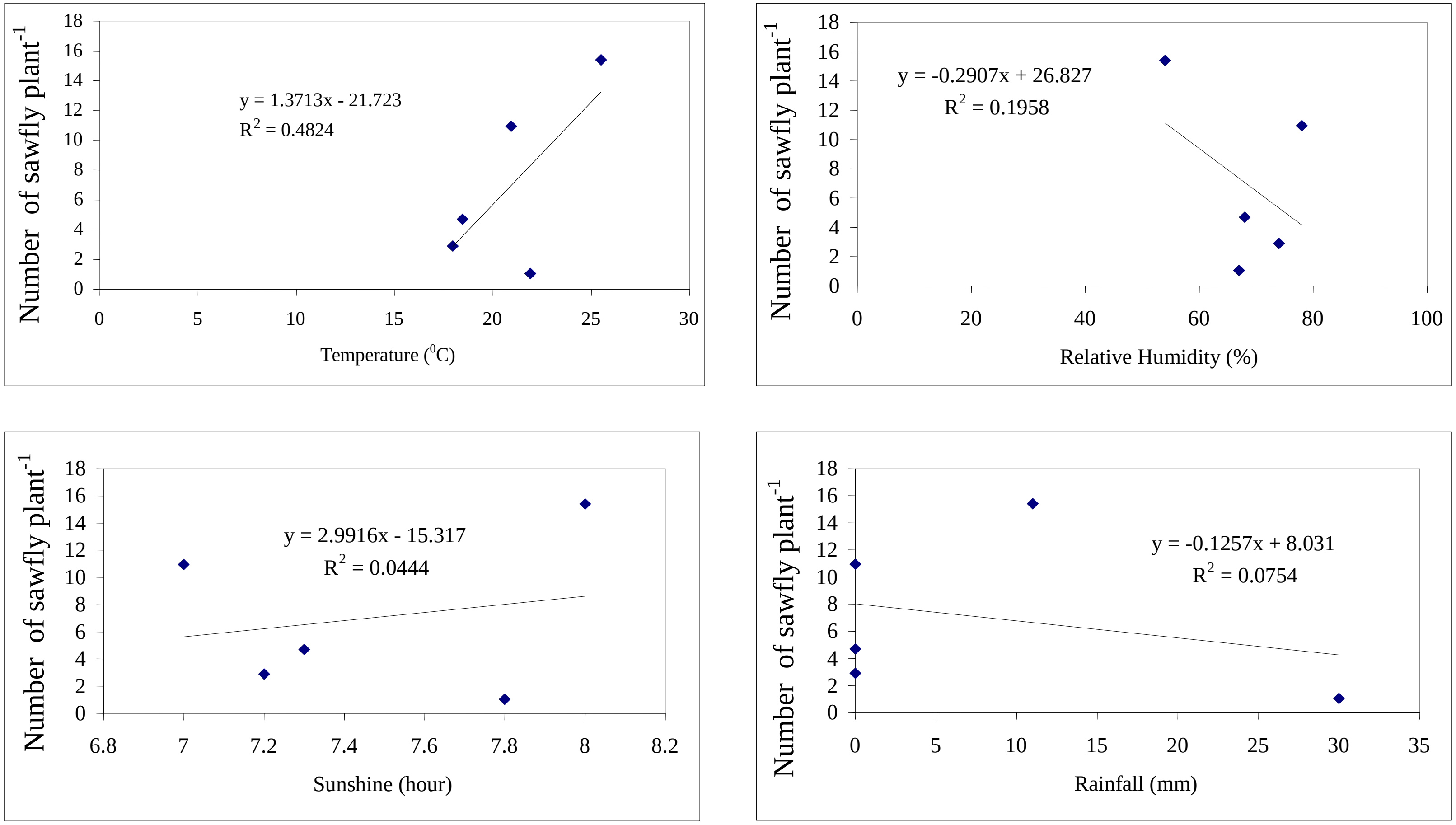

Figure 4. Sawfly incidence in relation to weather factor (temperature, relative humidity sunshine and rainfall) at fruiting stage

and T_3 (117.65) plot significantly the lowest number of siliqua per plant was recorded from T_5 (101.90) which was followed by T_1 (113.45) (Table4).The longest siliqua was recorded from T_4 (3.96 cm) which was statistically identical to that of T_2 (3.56 cm) and T_3 (3.42 cm) plots while the shortest siliqua was obtained from T_5 (3.08 cm) which was statistically identical with T_1 (3.12 cm) (Table 4), T_2 (3.36cm) and T_3 (3.42cm).

Significantly the highest number of seeds per siliqua was recorded from T_4 (29.45) which was numerically followed by T_2 (27.52) and T_3 (27.10) and latter two were statistically identical. On the other hand, significantly the lowest number of seeds per siliqua was recorded from T_5 (21.80) which was numerically followed by T_1 (24.86) (Table 4). The heighest weight of 1000 seeds was observed from T_4 (3.51 g) treated which was statistically identical to that of T_2 (3.40 g) and T_3 (3.33 g) plot. The lowest weight of 1000 seeds was recorded from T_5 (3.04 g) treated plot which was statistically identical with T_1 (3.15 g) and T_3 (3.33 g) Table 4).

The highest yield per ha was recorded from T_4 (2.34 t/ha) which was statistically similar to that of T_2 (2.26 t/ha) and T_3 (2.22 t/ha) plot, while significantly the lowest yield per ha was found from T_5 (2.01 t/ha) treated plot which was not significantly differ from that of with T_1 (2.09 t/ha) (Table 4). Ansari and Shazia (2004) reported that the incidence of *A. proxima* damage was significantly more at early stages of crop growth than later stage and that also lead to help attaining the highest yield contributing characters and yield of mustard. The incidence of mustard aphid (*Lipaphis erysimi*) started in the third week of November reaching to its peak (8.0 and 9.5 aphid/plant) in the second week of January and disappeared in the third week of February during both the years that greatly influence yield contributing characters and yield of mustard.(Gour Pareek,2003).

4.2 Sowing on 30 November, 2008

Statistically significant variation was recorded in number of aphid and sawfly at early, mid & late flowering stage and yield and yield contributing characters due to different management practices with environmental factors i.e; sowing mustard at 30 November, 2008.

4.2.1 Aphid infestation

In case of aphid incidence, at early flowering stage, significantly the lowest number of aphid (1.10) was observed from T_4 (Neem extract) treated plot which was followed (2.05 and 2.20) by T_2 (Zinger extract) and T_3 (Turmeric extract) and these are not significantly different .While significantly the highest number (9.22) was recorded from T_5 (control) treated plot, which was followed by T_1 (Confider as a seed treating chemical) (Table 5). At mid flowering stage, significantly the lowest number of aphid was recorded from T_4 (1.90), which was followed by T_2 (3.20). Whereas the highest number was found from T_5 (11.55) treated plot, which was followed by T_1 (6.05). At late flowering stage, the lowest number of aphid was observed from T_4 (2.15) treated plot, which was followed by T_2 (4.50) and T_3 (5.35) applied plot. Again, the highest number was found from T_5 (14.00), which were followed by T_1 (8.40) treated plot. Dhaliwal *et al.* (2005) showed that low minimum temperature, high morning relative humidity, and reduced solar radiation or sunshine hours favoured aphid incidence.

Table 4. Effect of different treatments on yield contributing characters and yield of mustard sowing on 23 November

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of siliqua plant^{-1}	Length of siliqua (cm)	Number of seed siliqua^{-1}	1000 seed weight (g)	Yield t ha^{-1}
T_1	108.75 c	10.45 bc	113.45 c	3.12 b	24.86 c	3.15 b	2.09 b
T_2	112.90 b	11.34 ab	119.10 b	3.56 ab	27.52 b	3.40 a	2.26 a
T_3	111.55 b	11.00 ab	117.65 b	3.42 ab	27.10 b	3.33 ab	2.22 a
T_4	116.40 a	12.85 a	122.55 a	3.96 a	29.45 a	3.51 a	2.34 a
T_5	101.80 d	10.10 c	101.90 d	3.08 b	21.80 d	3.04 b	2.01 b
Significance level	0.01	0.01	0.01	0.05	0.05	0.01	0.01
CV(%)	7.56	8.92	9.43	11.23	5.34	9.51	4.65

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical) T_2: Zinger extract
T_3: Turmeric extract T_4: Neem extract
T_5: Control

At early fruiting stage, significantly the lowest number of aphid was recorded from T_4 (2.45) which was not statistically identical with T_2 (4.30), T_3 (4.75) and T_1 (5.30) treated plot, but these was significantly differ among there. The highest number was recorded from T_5 (11.80) (Table 5) untreated control plot. At mid fruiting stage, the lowest number of aphid was obtained from T_4 (3.20), which was followed by T_2 (4.60). While the highest number was recorded from T_5 (13.65), which was followed by T_1 (6.10).Simillar statistical relationship was obtained as calculated at early stage. At late fruiting stage, significantly the lowest number of aphid was found from T_4 (3.75) treated plot, which was followed by T_2 (4.20) and T_3 (4.65) treated plot. Again,significantly the highest which infestation was recorded from T_5 (16.30) control plot. Prabal *et al*. (2000) reported maximum aphid mortality (97.50%) was observed at neem seed kernel extract, followed by neem leaf extract at 10% (61.88%).

4.2.2 Sawfly infestation

In case of sawfly incidence, at early flowering stage, lowest number sawfly was found in T_4 (0.20) treated plot, which was statistically similar to those of T_2 (1.10) and T_3 (1.35) treated plot. On the other hand, highest number of sawfly was obtained from T_5 (5.10) treated plot, which was followed by T_1 (2.75) and these were significantly different .At mid flowering stage, again no sawfly was obtained from T_4 (0.00) treated plot, which was followed by T_2 (0.55) and T_3 (0.80) treated plot. Again the highest number was found from T_5 (3.60), which was followed by T_1 (1.25) and these were significantly different from each other. At late flowering stage, the lowest number of sawfly was recorded from T_4 (0.00), which was statistically similar with

Table 5. Effect of different treatments on mustard aphid during flowering and fruiting stage of mustard sowing on 30 November

Treatments	Number of aphid plant^{-1}					
	Flowering stage			Fruiting stage		
	Early	Mid	Late	Early	Mid	Late
T_1	3.10 b	6.05 b	8.40 b	5.30 b	6.10 b	7.10 b
T_2	2.05 c	3.20 d	4.50 c	4.30 b	4.60 c	4.20 c
T_3	2.20 bc	4.85 c	5.35 c	4.75 b	5.95 b	4.65 c
T_4	1.10 d	1.90 e	2.15 d	2.45 c	3.20 d	3.75 c
T_5	9.22 a	11.55 a	14.00 a	11.80 a	13.65 a	16.30 a
Significance level	0.01	0.01	0.05	0.01	0.05	0.01
CV(%)	16.02	7.33	8.91	6.54	11.12	5.56

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical) T_2: Zinger extract
T_3: Turmeric extract T_4: Neem extract
T_5: Control

T_2 and followed by T_3 (0.20), whereas the highest number was obtained from T_5 (2.25), which was followed by T_1 (0.95) (Table 6). At early fruiting stage, the lowest number of sawfly was found from T_4 (1.15), which was followed by T_2 (3.20), T_3 (3.45) and T_1 (3.90) again, the highest from T_5 (6.10). At mid fruiting stage, the lowest number of sawfly was recorded from T_4 (1.05), which was followed by T_2 (2.65), whereas the highest number was observed from T_5 (5.40), which was followed by T_1 (3.65). At late fruiting stage, the lowest number of sawfly was recorded from T_4 (0.65), which was followed by T_2 (1.35) and T_3 (1.55), whereas the highest number was found from T_5 (4.10) (Table 6). Similar findings also reported by Bhat and Bapodra (2004) and Gour and Pareek (2003) earlier. Gour and Pareek (2003) studied on the seasonal incidence of major insect pests of mustard during the rabi season of 1999-2000 and 2000-2001 under the semi-arid conditions of Rajasthan, India revealed that mustard sawfly (*A. lugens*) appeared in the fourth week of October, reached its peak (0.4 and 0.6 grub/plant) and continued up to the first week of December during both years. The pained bug (*B. hilaris*) appeared in the fourth week of October, reaching its maximum (1.8 and 1.2 bug/plant) in the third week of November and persisted up to third week of January. The incidence of mustard aphid (*L. erysimi*) started in the third week of November reaching to its peak (8.0 and 9.5 aphid/plant) in the second week of January and disappeared in the third week of February during both the years.

Table 6. Effect of different treatments on sawfly during flowering and fruiting stage of mustard sown on 30 November

Treatments	Number of sawfly plant^{-1}					
	Flowering stage			Fruiting stage		
	Early	Mid	Late	Early	Mid	Late
T_1	2.75 b	1.25 b	0.95 b	3.90 b	3.65 b	2.20 b
T_2	1.10 c	0.55 c	0.00 d	3.20 b	2.65 c	1.35 c
T_3	1.35 c	0.80 bc	0.20 c	3.45 b	3.10 b	1.55 bc
T_4	0.20 d	0.00 d	0.00 d	1.15 c	1.05 d	0.65 d
T_5	5.10 a	3.60 a	2.25 a	6.10 a	5.40 a	4.10 a
Significance level	0.01	0.01	0.05	0.01	0.05	0.01
CV(%)	12.12	5.92	7.09	7.93	10.89	9.03

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical) T_2: Zinger extract
T_3: Turmeric extract T_4: Neem extract
T_5: Control

4.2.3 Yield and yield contributing characters

For plant height, significantly the longest plant was recorded from T_4 (114.35 cm) treated plot which was identical with T_2 (112.84 cm) and T_3 (109.22 cm) and these were statistically similar. On the other hand, significantly the shortest plant was observed from T_5 (100.54 cm) which was followed by T_1 (105.10 cm) (Table 7). In case of number of branches per plant, the highest number of branches per plant was found from T_4 (13.02) treated plot which was statistically identical to those of T_2 (12.89) and T_3 (12.81) treated plot .Again the lowest number of branches per plant was recorded from T_5 (10.76) which was followed by T_1 (11.02) (Table 7).

Significantly the highest number of siliqua per plant was obtain from T_4 (128.10) treated plot which was numerically followed by T_2 (122.40) and T_3 (121.55) plot. On the other hand the lowest number of siliqua per plant was obtained from T_5 (103.00) which was followed by T_1 (115.15) (Table 7). The longest siliqua was recorded from T_4 (4.12 cm) which was statistically identical to that of T_2 (4.04 cm) and T_3 (4.00 cm) while the shortest siliqua was obtained from T_5 (3.56 cm) which was followed by T_1 (3.88 cm) (Table 7). Raj *et al.* (2007) also reported similar findings earlier.

Significantly the highest number of seeds per siliqua was found from T_4 (32.20) which was statistically identical with T_2 (30.40) and numerically followed by T_3 (29.75) and T_1 (29.88. On the other hand, significantly the lowest number of seeds per siliqua was recorded from T_5 (25.32) (Table 7). The highest weight of 1000 seeds was recorded from T_4 (3.72 g) treated plot which was followed by T_2 (3.59 g) T_1 (3.52 g) and T_3 (3.51 g) plot.

Table 7. Effect of different treatments on yield contributing characters and yield of mustard sown on 30 November

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of siliqua plant^{-1}	Length of siliqua (cm)	Number of seed siliqua^{-1}	1000 seed weight (g)	Yield t ha^{-1}
T_1	105.10 b	11.02 b	115.15 c	3.88 b	29.88 b	3.52 b	2.33 c
T_2	112.84 a	12.89 ab	122.40 b	4.04 ab	30.40 ab	3.59 b	2.48 b
T_3	109.22 ab	12.81 ab	121.55 b	4.00 ab	29.75 b	3.51 b	2.41 b
T_4	114.35 a	13.02 a	128.10 a	4.12 a	32.20 a	3.72 a	2.64 a
T_5	100.54 c	10.76 c	103.00 d	3.56 c	25.32 c	3.22 c	2.02 d
Significance level	0.01	0.01	0.01	0.01	0.05	0.01	0.01
CV(%)	8.22	7.99	5.22	6.77	13.06	5.34	8.22

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical)
T_2: Zinger extract
T_3: Turmeric extract
T_4: Neem extract
T_5: Control

The lowest weight of 1000 seeds from T_5 (3.22 g) (Table 7). The highest yield per ha was obtained from T_4 (2.64 t/ha) which was statistically similar to that of T_2 (2.48 t/ha) and T_3 (2.41 t/ha) plot, while significantly the lowest yield was recorded from T_5 (2.02 t/ha) plot which was not significantly differ that of T_1 (2.33 t/ha) (Table 7). Dhaliwal and Hundal (2004) reported optimum date of sowing was during the first week of October (early sowing), followed by 30 October and 25 November regarding yield contributing characters and yield of mustard.

4.3 Sowing on 06 December, 2008

Significant variation was recorded in number of aphid and sawfly at early, mid & late flowering stage and yield and yield contributing characters due to different management with environmental factors i.e; sowing mustard at 06 December, 2008.

4.3.1 Aphid infestation

In case of aphid incidence, at early flowering stage, significantly the lowest number of aphid (2.65) was recorded from T_4 (Neem extract) treated plot, which was followed (3.80 and 4.10) by T_2 (Zinger extract) and T_3 (Turmeric extract), and these are not significantly different .While significantly the highest number (11.50) was found from T_5 (control) plot, which was followed (5.05) by T_1 (Confider as a seed treating chemical) (Table 8). At mid flowering stage, significantly the lowest number of aphid was recorded from T_4 (3.12) which was followed by T_2 (4.32), while the highest number from T_5 (12.55) plot, which was followed by T_1 (5.65). At late flowering stage, the lowest number of aphid was recorded from T_4 (3.85) treated plot, which was followed by T_2 (5.10). Again, the highest number from T_5 (15.33) which were followed by T_1 treated plot (8.92).At early fruiting stage, significantly the lowest number of aphid was recorded from T_4 (2.90), which was not statistically identical with T_2 (5.65) and T_3 (6.25), while the highest number was recorded from T_5 (14.10) untreated control plot (Table 8). At mid fruiting stage, the lowest number of aphid was observed from T_4 (3.56), which was followed by T_3 (46.02). Whereas the highest number from T_5 (16.14), which was followed by T_1 (9.25).Similar statistical relationship was obtained as calculated at early stage. At late fruiting stage, significantly the lowest number of aphid was found from T_4 treated plot (4.15), which was followed by T_2 (7.35) and T_3 (7.60) treated plot with no significant difference between the later. Significantly the highest from T_5 (17.65) control plot. Jat *et al.* (2006) carried out a field experiment during 2002-03, in Bikaner, Rajasthan, India, to evaluate the correlation between meteorological factors and infestation of Indian mustard by sawfly (*A. lugens*), painted bug (*B. cruciferarum)* and aphid (*L. erysimi*). Sawfly infestation was observed from the first week after sowing up to the 4th week during rabi 2002-03. Sawfly population peaked (6 grubs per 5 plants) during the 2nd week of November, with maximum and minimum temperatures of 32.1 and 16.3 degrees C and relative humidity of 60% in the morning and 23% in the evening. Similarly painted bug infestation started at the time of germination (1st to 4th week), which increased gradually and peaked (85 bugs per 5 plants) in the 3rd week of November. The effect of weather factors on the population build-up of the painted bug was not significant. Aphid infestation started in the 3rd week of January (48 aphid per 5 plants), which increased gradually and peaked (295 aphids per 5 plants) in the 2nd week of February and disappeared completely after the 2nd week of March. Aphid population was significantly and positively correlated with both morning and evening relative humidity.

4.3.2 Sawfly infestation

In case of sawfly incidence, at early flowering stage, the lowest number of sawfly was found in T_4 (1.20) treated plot, which was followed by T_2 (2.80), T_3 (3.10) and T_1 (3.80) treated plot. On the other hand, the highest number of sawfly was obtained from T_5 (6.25) control plot and these were significantly different. At mid flowering stage, the lowest number of sawfly was obtained from T_4 (0.65) treated plot, which was followed by T_3 (1.50) and T_2 (1.55). Again the highest number was found from T_5 (3.95), which was followed by T_1 (1.65) and these were significantly different from each other. At late flowering stage, no incidence was appeared in T_4. The lowest number of sawfly was recorded from T_2 (0.55), whereas the highest number (3.60) recorded from T_5 which was followed by T_1 (1.45) (Table 9).

At early fruiting stage, the lowest number of sawfly was obtained from T_4 (2.25), which was followed by T_3 (4.10) and T_2 (4.15) plots. On the other hand significantly the highest was recorded from T_5 (7.15), which was followed by T_1 (5.40). At mid fruiting stage, the lowest number of sawfly was recorded from T_4 (2.05) plot, which was followed by T_2 (3.45) and T_3 (3.60) whereas significantly the highest number was recorded from T_5 (5.65), which was followed by T_1 (4.10). At late fruiting stage,

the lowest number of sawfly was recorded from T_4 (1.20), which was statistically identical to those of T_3 (1.95) and T_2 (2.05) treated plot. Significantly the highest number was obtained from T_5 (4.75), which was followed by T_1 (2.80) (Table 9).

Table 8. Effect of different treatments on mustard aphid during flowering and fruiting stage of mustard sown on 06 December

Treatments	Number of aphid plant^{-1}					
	Flowering stage			Fruiting stage		
	Early	Mid	Late	Early	Mid	Late
T_1	5.05 b	5.65 b	8.92 b	8.90 b	9.25 b	9.90 b
T_2	3.80 c	4.32 c	5.10 d	5.65 c	6.02 c	7.35 c
T_3	4.10 c	5.02 b	6.65 c	6.25 c	5.95 d	7.60 c
T_4	2.65 d	3.12 d	3.85 e	2.90 d	3.56 e	4.15 d
T_5	11.50 a	12.55 a	15.33 a	14.10 a	16.14 a	17.65 a
Significance level	0.05	0.01	0.01	0.01	0.01	0.05
CV(%)	11.34	5.25	7.02	13.78	9.34	10.33

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical) T_2: Zinger extract
T_3: Turmeric extract T_4: Neem extract
T_5: Control

Mishra and Kanwat (2003) reported negative correlation was observed between aphid population and maximum and minimum temperatures, whereas a significant positive correlation was observed between aphid population and relative humidity.

4.3.3 Yield and yield contributing characters

In context of plant height, significantly the longest plant was found from T_4 (111.72 cm) treated plot, which was followed by T_2 (111.32 cm), T_3 (110.45 cm) and T_1 (109.50 cm) and this were statistically similar. On the other hand, significantly the shortest plant was recorded from T_5 (107.30 cm) (Table 10). For number of branches per plant, the highest number of branches per plant was obtained from T_4 (11.22) treated plot which was statistically identical to those of T_3 (10.85) and T_3 (10.70) treated plots. Again the lowest number of branches per plant was found from T_5 (10.05, which was statistically similar to those of T_1 (10.55) (Table 10).

Significantly the highest number of siliqua per plant was obtained from T_4 (199.22) treated plot, which was numerically followed by T_2 (115.70) and T_3 (114.25) plot. Significantly the lowest number of siliqua per plant was obtained from T_5 (102.15), which was followed by T_1 (111.55) (Table 10). The longest siliqua was recorded from T_4 (3.94 cm) which was statistically identical to that of T_2 (3.76 cm) and T_3 (3.64 cm) while the shortest siliqua was observed from T_5 (3.12 cm) which was statistically identical with T_1 (3.45 cm) (Table 10).

Significantly the highest number of seeds per siliqua was found from T_4 (29.44) which was numerically followed by T_3 (27.10) and T_2 (26.90) and latter two were statistically identical. On the other hand, significantly the lowest number of seeds per siliqua was obtained from T_5 (22.12) which was numerically followed by T_1 (24.25) (Table 10). The highest weight of 1000 seeds was recorded from T_4 (3.42 g) treated plot which was statistically identical to that of T_2 (3.33 g), T_3 (3.31 g) and T_1 (3.28 g) plots. The lowest weight of 1000 seeds was recorded from T_5 (3.12 g) control plot (Table 10).

The highest yield per ha was recorded from T_4 (2.21 t/ha) which was statistically similar to that of T_3 (2.18 t/ha) and T_2 (2.17 t/ha) plot,while significantly the lowest yield was found from T_5 (1.95 t/ha) control plot which was not statistically differ from that of T_1 (2.04 t/ha) (Table 10).Deepak *et al.* (2002) reported that yield contributing characters and yield of mustard due to the peak population was during the last week of December when the maximum temperature was 24.1 degrees C, minimum temperature was 9.0 degrees C, relative humidity was 94% in the morning and 33% in the evening, wind was velocity 2.1 kmph and there was no rainfall.

Table 9. Effect of different treatments on sawfly during flowering and fruiting stage of mustard sown on 06 December, 2008

Treatments	Number of sawfly plant^{-1}					
	Flowering stage			Fruiting stage		
	Early	Mid	Late	Early	Mid	Late
T_1	3.80 b	1.65 b	1.45 b	5.40 b	4.10 b	2.80 b
T_2	2.80 b	1.55 b	0.55 c	4.15 b	3.45 c	2.05 bc
T_3	3.10 b	1.50 b	0.60 c	4.10 b	3.60 c	1.95 bc
T_4	1.20 c	0.65 c	0.00 d	2.25 c	2.05 d	1.20 c
T_5	6.25 a	3.95 a	3.60 a	7.15 a	5.65 a	4.75 a
Significance level	0.01	0.05	0.05	0.05	0.01	0.01
CV(%)	5.05	7.23	6.11	9.03	4.44	12.33

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical) T_2: Zinger extract
T_3: Turmeric extract T_4: Neem extract
T_5: Control

Table 10. Effect of different treatments on yield contributing characters and yield of mustard sown on 06 December

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of siliqua plant^{-1}	Length of siliqua (cm)	Number of seed siliqua^{-1}	1000 seed weight (g)	Yield t ha^{-1}
T_1	109.50 a	10.55 ab	111.55 c	3.45 c	24.25 c	3.28 a	2.04 b
T_2	111.32 a	10.85 ab	115.70 b	3.76 b	26.90 b	3.33 a	2.17 a
T_3	110.45 a	10.70 ab	114.25 b	3.64 b	27.10 b	3.31 a	2.18 a
T_4	111.72 a	11.22 a	119.22 a	3.94 a	29.44 a	3.42 a	2.21 a
T_5	107.30 b	10.05 b	102.15 d	3.12 d	22.12 d	3.12 b	1.95 b
Significance level	0.01	0.05	0.01	0.01	0.01	0.05	0.01
CV(%)	4.13	9.09	6.56	10.02	7.33	11.72	13.54

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1: Confider 70WG (Seed treating chemical) T_2: Zinger extract
T_3: Turmeric extract T_4: Neem extract
T_5: Control

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted to study the effect of a seed treating chemical and three plant extracts for the management of aphid and sawfly infesting mustard in relation to sowing time. The experiment was undertaken in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November 2008 to March 2009. The environmental factors were evaluated for different the sowing time i.e; sowing at 23 November, 30 November and 06 December, 2008. The experiment comprised of the following treatments; T_1: Confider 70WG @ 3 g/kg seeds; T_2: Zinger extract @ 20 ml/L water at 7 days interval; T_3: Turmeric extract @ 20 ml/L water at 7 days interval; T_4: Neem leaf extract 20 ml/L water at 7 days interval and T_5:untreated Control. Three experiments were laid out in three sowing times. Each experiment was set in Randomized Complete Block Design (RCBD) with three replications.

At early flowering stage the lowest number of aphid (0.55) was recorded from T_4, while the highest number (7.56) from T_5 treated plot of mustard sown 23 November, 2008. At mid flowering stage, the lowest number of aphid was obtained from T_4 (1.15), again the highest from T_5 (9.75). At late flowering stage, the lowest number of aphid was observed from T_4 plot (1.50) again, the highest number from T_5 (11.60) untreated plot. At early fruiting stage, the lowest number of aphid was recorded from T_4 treated plot (1.85), while the highest number from T_5 (8.20) untreated plot. At mid fruiting stage, the lowest number of aphid was recorded from T_4 (2.00) treated plot, whereas the highest number from T_5 (9.55) control plot. At late fruiting stage, the lowest number of aphid was observed from T_4 (3.15) treated plot while, the highest from T_5 (13.20) control plot. In case of sawfly incidence, at early flowering stage, the lowest number of sawfly was recorded from T_4 (0.00) treated plot and, the highest number from T_5 (4.65) untreated plot. At mid flowering stage, the lowest number of sawfly was found from T_4 (0.00) treated plot, again the highest number from T_5 (2.30) untreated plot. At late flowering stage, no incidence was appeared for T_4 and T_2 and the highest number (1.85) from T_5. At early fruiting stage, the lowest number of sawfly was observed from T_4 (0.70) and the highest from T_5 (5.60). At mid fruiting stage, the lowest number of sawfly was recorded from T_4 (0.35) whereas the highest number from T_5 (5.10). At late fruiting stage, the lowest number of sawfly was recorded from T_4 (0.00), again the highest number from T_5 (4.70). The longest plant was found from T_4 (116.40 cm) and, the shortest from T_5 (101.80 cm). In number of siliqua per plant, the highest number of siliqua per plant was observed from T_4 (122.55) whereas the lowest number from T_5 (101.90). In the context of the seeds yield per hectare the highest yield was recorded from T_4 (2.34 t/ha), while the lowest from T_5 (2.01 t/ha).

At early flowering stage, the lowest number of aphid was observed from T_4 (1.10), whereas the highest number from T_5 (9.22) treated plot of mustard sown 30 Novembe,2008. At mid flowering stage, the lowest number of aphid was recorded from T_4 plot (1.90), whereas the highest number from T_5 (11.55) untreated plot. At late flowering stage, the lowest number of aphid was observed from T_4 (2.15) again, the highest number from T_5 (14.00). At early fruiting stage, the lowest number of aphid was recorded from T_4 (2.45), while the highest number from T_5 (11.80). At mid fruiting stage, the lowest number of aphid was obtained from T_4 (3.20), while the highest number from T_5 (13.65). At late fruiting stage, the lowest number of aphid was found from T_4 (3.75) treated plot.Again, the highest from T_5 (16.30). In case of sawfly incidence, at early flowering stage, the lowest number of sawfly was recorded from T_4 (0.20) treated plot, whereas the highest number from T_5 (5.10). At mid flowering stage, the lowest number of sawfly was obtained from T_4 (0.00), whereas the highest number from T_5 (3.60). At late flowering stage, the lowest number of sawfly was recorded from T_4 (0.00), whereas the highest number from T_5 (2.25). At early fruiting stage, the lowest number of sawfly was found from T_4 (1.15) again, the highest from T_5 (6.10). At mid fruiting stage, the lowest number of sawfly was recorded from T_4 (1.05), whereas the highest number from T_5 (5.40). At late fruiting stage, the lowest number of sawfly was recorded from T_4 (0.65), whereas the highest number from T_5 (4.10). The longest plant was recorded from T_4 (114.35 cm) whereas the shortest plant from T_5 (100.54 cm). For number of siliqua per plant, the highest number was recorded from T_4 (128.10) and the lowest number from T_5 (103.00). Considering the seeds yield per hectare, the highest yield was obtained from T_4 (2.64 t/ha), while the lowest yield was recorded from T_5 (2.02 t/ha).

At early flowering stage, the lowest number of aphid was recorded from T_4 (2.65) treated plot, while the highest number from T_5 (11.50) treated plot of mustard sown 06 December, 2008. At mid flowering stage, the lowest number of aphid was recorded from T_4 (3.12) treated plot, while the highest number from T_5 (12.55). At late flowering stage, the lowest number of aphid was recorded from T_4 (3.85) treated plot, again, the highest number from T_5 (15.33) control plot. At early fruiting stage, the lowest number of aphid was recorded from T_4 (2.90), while the highest number from T_5 (14.10). At mid fruiting stage, the lowest number of aphid was observed from T_4 (3.56), whereas the highest number from T_5 (16.14). At late fruiting stage, the lowest number of aphid was found from T_4 (4.15) while, the highest from T_5 (17.65). In case of sawfly incidence, at early flowering stage, the lowest number of sawfly was recorded from T_4 (1.20) and the highest number from T_5 (6.25). At mid flowering stage, the lowest number of sawfly was obtained from T_4 (0.65), again the highest number from T_5 (3.95). At late flowering stage, no incidence was appeared for T_4 and the highest number (3.60) from T_5. At early fruiting stage, the lowest number of sawfly was obtained from T_4 (2.25) whereas, the highest from T_5 (7.15). At mid fruiting stage, the lowest number of sawfly was recorded from T_4 (2.05) whereas the highest number from T_5 (5.65). At late fruiting stage, the lowest number of sawfly was recorded from T_4 (1.20), while the highest number from T_5 (4.75). The longest plant was found from T_4 (111.72 cm) whereas the shortest plant from T_5 (107.30 cm). Considering the number of siliqua per plant, the highest number of siliqua per plant was recorded from T_4 (199.22) and, the lowest number from T_5 (102.15). In the context of the seeds yield per hectare the highest yield was recorded from T_4 (2.21 t/ha) and the lowest yield from T_5 (1.95 t/ha).

The above results indicate that sowing on 23 November and application of neem leaf extract @ 20.0 ml/L of water showed best performance for the management of mustard aphid

Considering the experiment in the present studies, further studies in the following areas may be suggested:

1. Study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability of the aphid and sawfly;
2. Other sowing time may be included in the future study;
3. Management practices utilizing different plant extracts considering different sowing time may be included in the future study.

CHAPTER VI
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CHAPTER VII
APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from November 2008 to March 2009

Month	*Air temperature (^oC)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
November, 2008	25.82	16.04	78	00
December, 2008	22.4	13.5	74	00
January, 2009	24.5	12.4	68	00
February, 2009	27.1	16.7	67	30
March, 2009	31.4	19.6	54	11

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix II. Characteristics of experimental field soil as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45