IMPACT OF SOME PROMISING INSECTICIDES ON APHID INFESTATION, ITS PREDATORY LADYBIRD BEETLE AND OTHER SOIL INSECTS IN MUSTARD FIELD

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CERTIFICATE

This is to certify that the thesis entitled, "IMPACT OF SOME PROMISING INSECTICIDES ON APHID INFESTATION, ITS PREDATORY LADYBIRD BEETLE AND OTHER SOIL INSECTS IN MUSTARD FIELD" submitted to the Department of Entomology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) IN ENTOMOLOGY, embodies the result of a piece of bonafide research work carried out by MOHAMMAD RASHEDUL ISLAM, Registration No. 05-01828 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June 2011
SAU, Dhaka

(Prof. Dr. Md. Razzab Ali)
Supervisor

Dedicated

to

My Beloved Parents

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The author

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

IMPACT OF SOME PROMISING INSECTICIDES ON APHID INFESTATION, ITS PREDATORY LADYBIRD BEETLE AND OTHER SOIL INSECTS IN MUSTARD FIELD

ABSTRACT

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the Rabi season 2010-2011 to evaluate the effectiveness of some promising insecticides on aphid infestation as well as their impacts on the incidence of predatory ladybird beetle and other soil insects in mustard field. The treatments were composed of five promising chemical insecticides and one untreated control viz., foliar spray of Malathion 57 EC @ 2 ml/l of water, Sevin 85 WP @ 4 g/l of water, Marshal 20 EC @ 2 ml/l of water, Aktara 25 WG @ 0.5 g/l of water, Ripcord 10 EC @ 3 ml/l of water and an untreated control. Among five insecticides, Ripcord 10 EC performed as the most effective insecticide in reducing the highest percent of aphid population (163.33%) over control followed by Aktara, Marshal, Malathion and Sevin, whereas Sevin 85 WP showed the least performance (33.76%). Conversely, Aktara 25WG performed as the most effective insecticide and reduced the highest percent of pod infestation (160.46%) and pod deformation (144.29%) over control, but increased the highest percent of pod formation (17.20%), 1000 seed weight (30.00%) and yield (23.68%) of mustard over control than Ripcord, Malathion, Sevin and Marshal. Considering the impact of insecticides on the population of ladybird beetle and other soil insects, Aktara 25WG performed as the most hazardous insecticide in terms of reducing the highest percent of ladybird beetle larvae (100.00%) by visual count over control than Ripcord, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ladybird beetle larvae (5.82%). Conversely, Ripcord 10EC 3 ml/Litre of water performed as the most hazardous insecticide in terms of reducing the highest percent of adult ladybird beetle by visual counts (149.25%) and pitfall trap (86.56%) as well as ladybird beetle larvae by pitfall trap (65.06%) over control than Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of adult ladybird beetle by visual count (7.25%) and pitfall trap (11.87%) over control as well as ladybird beetle larvae by pitfall trap (8.48%) over control. Ripcord 10EC 3 ml/l of water performed as the most hazardous insecticide in reducing the highest percent of ant population (107.43%) and other soil insects (149.98%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ant population (33.34%) and other soil insects (35.21%).

CHAPTER I

INTRODUCTION

Mustard is one of the important oleiferous crops and constitute major source of edible oil for the human consumption and cake for animals. Mustard plant belongs to the genus *Brassica* under the family Cruciferae. In our country, mainly three species are cultivated namely, *Brassica campestris*, *Brassica juncea* and *Brassica napus*. Mustard varieties such as Tori-7, Sampad (both are *B. campestris*) and Doulot (*B. juncea*) are mainly grown in this country. This crop is well adapted to almost all agro-climatic zones and grows in Rabi season. It occupies an area of 2,42,000 ha land and produces about 2,22,000 ton of oilseeds per year. The production rate of mustard is 916.00 kg/ha in Bangladesh (BBS, 2010). Among the oil seed crops, mustard is the main edible oilseed crop of Bangladesh and its performance in total oilseed production is approximately 70 percent. It occupies first position in the list in respect of area and production among the oilseed crops grown in this country (BBS, 2004). Annual requirement of edible oil for Bangladesh is 0.5 million metric tons. That is, the internal production of edible oil can meet up only less than one-third of the annual requirement of Bangladesh and it has been in short of 65 to 70% of the requirement. As a result, a huge amount of foreign currency is spent every year for importing oil and oilseed from abroad. Mustard seed contain 40-45% oil and 20-25% protein. Using local ghani average 33% oil may be extracted (Mondal and Wahab, 2001). It is not only a rich source of energy (about 9 kcal/gm), but also rich in soluble vitamins A, D, E and K. The national nutrition council (NCC) of Bangladesh reported that recommended dietary allowance (RDA) per capita per day is 6 gm of oil for a diet with 2700 kcal (USDA, 2011). Oil cake is also a nutritious food item for cattle and fish as well as used as good organic fertilizer. The oil cake has a very low content of the glucosinolates responsible for metabolic disruption in cattle and pigs (USDA, 2011). Rapeseed produces great amounts of nectar, and honeybees produce a light colored, but peppery honey from it. Rapeseed oil is the preferred oil stock for biodiesel production in most of Europe, accounting for about 80% of the feedstock (Anonymous, 2011). This crop is also one of the most important oilseed crops throughout the world after soybean and groundnut (FAO, 2004). World production is growing rapidly, with FAO reporting that 36 million tones of mustard was produced in the 2003-2004 season and estimates of 58.4 million tons in the 2010-2011 seasons (USDA, 2011). Worldwide production of mustard has increased six fold between 1975 and 2007.

The average yield of mustard per ha is very low in Bangladesh. One of the factors responsible for such low yield is the ravage of insect pest attacking at various stages of the crop. More than three dozen of insect pests are known to be associated with various phonological stages of rapeseed-mustard crops in India (Singh & Singh, 1983 and Bakhetia & Sekhon, 1989). Insect pest infestation plays a limiting factor in mustard production. Among different insect pest complex, Bangladesh and elsewhere Mustard aphid, *Lipaphis erysimi* (Kalt) is the most serious and destructive pest of mustard and a major limiting factor for successful cultivation of mustard seed production (Biswas *et. al.*, 2000 and Begum *et. al.*, 1995) and has attained the level of key pest. Mustard aphid belongs to the superfamily Aphidoidea of the order Homoptera. Both nymphs and adults of this pest cause damage to mustard plants from early vegetative to siliqua maturity stage (Verma, 1987) by de-sapping inflorescence, flower and pods, resulting stunted growth of the plant, flowers wither and pod formation is hindered. Although aphid is a minute insect it may destroy the plants even quicker than larger insects and adversely affects the productivity. Honeydews secreted by aphids are favorite medium for the development of sooty mold on plants. As a result, crop gets black and dies before bearing of seeds. Increase in population beyond 9.45 aphids per plant; reduce the seed yield by 59.3 percent with an economic injury level of 2.04 aphids/plants and infestation of 37.4 percent (Singh & Malik, 1998). The yield reduction of mustard due to aphids varied from 30-40% in our country depending upon the season (Biswas, 2000; Begum, 1995 and Rohilla, 2004). In case of severe aphid infestation, leaves become curled, plant fails to develop pods, the young pods when developed fail to become mature and cannot produce healthy seeds. As a result, plants lose their vigor and growth becomes stunted (Morzia and Huq, 1991; Das, 1986). Greatest loss in yield due to mustard aphid (*Lipaphis eyrsimi* Kalt.) is 83% to rapeseed and mustard in India (Mandal *et al.*, 1994). Losses due to insect pests are estimated to be 70-80% in Pakistan. But in case of severe infestation in the years of sporadic attack there may be no grain formation at all (Khattak *et al.* 2002).

The use of synthetic chemical pesticides has accounted for astonishing gains in production, as the pesticides have reduced the hidden toll exacted by the aggregated attack of insect-pests. Keeping in view the importance of this crop and its substantial loss by Brassica aphids, farmers generally spray insecticides in their field. Said (2005) reported that chemical insecticides reduced aphid population on mustard with application of Curacron (43.45 aphid per inch of inflorescence), followed by Ripcord, Actara, Bestox, Karate, Thiodan, Lorsban, Advantage, Methamidophos and Sevin with 26.31, 26.92, 27.68, 30.45, 31.26, 33.79, 37.32, 42.32 and 43.77 aphid per cm of inflorescence respectively. Amer (2010) reported that the lowest numbers of aphids were observed where Talstar was applied as compared to Advantage, Actara and Confidor. Bakhetia (1984) and Khurana *et al.* (1989) also reported that good control of mustard aphid have been obtained by spraying traditional organic insecticides. Mannan (2002) reported that different doses (1 ml, 2 ml, 3 ml/l water) of Malathion 57 EC were more effective than same doses of Diazinon 60 EC for the control of aphids and it was less toxic to the predator and other beneficial insects. The lower dose of insecticides has less adverse effect on the predator and other beneficial insects than the higher dose. Sing and Sircar (1983) reported that most toxic compounds against eight species of aphids and *C. septempunctata* were Phorate, Dimethoate and Carbaryl, whereas Endosulfan, Lindane and Phidan were effective against aphid and relatively safe against *C. septempunctata*. The indiscriminate uses of synthetic insecticides cause resistance of this insect pest, destruction of beneficial organisms and environmental pollution (McIntyre, 1989). Therefore, it is necessary to find out the ecologically sound and environmentally safe methods for this aphid control.

The predacious coccinellid beetles, commonly known as lady bird beetles are considered to be of great economic importance in the agro-ecosystem. They have been successfully employed in the bio-control to many injurious insects (Agarwala *et al.*, 1988). In the field, mustard aphid population is naturally controlled to a large extent by its predator *Coccinella septempunctata* and plays a vital role in lowering the population of mustard aphid in the field (Kalra, 1988). For controlling the mustard aphid successfully and to save *C. septempunctata*, insecticides should be applied at appropriate dose and at right time.

Considering these facts as stated above, the present investigation was undertaken with the following objectives:

1. to find out the level of infestation caused by aphids on mustard;
2. to explore the effectiveness of different insecticides on the reduction of aphid infestation on mustard;
3. to evaluate the impact of insecticides on the lady bird beetle and other beneficial insects during the management of mustard aphid in the field.

CHAPTER II

REVIEW OF LITERATURE

Mustard aphid, *Lipaphis erysimi* (Kalt.) is one of the most important insect pests of cruciferous crops in Bangladesh. Good number of research works has been done on different aspects of mustard in different parts of the world. Although considerable literature dealing with loss occurred due to aphid infestation, effect of different insecticides on aphid infestation and reducing the loss occurred by aphid with treating different dose of insecticide and increasing the yield are available. Some of the works related to the present study have been presented below under the following sub-headings:

2.1 General review on mustard aphid and ladybird beetle

Literature dealing with taxonomy, distribution and host range of mustard aphid, *L. erysimi*, extent of damage and yield loss caused by mustard aphid have been presented below:

2.1.1. Taxonomy of mustard aphid

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

Taxonomic position of mustard aphid

Kingdom: Animalia

Class : Insecta

Sub-Class: Pterygota

Division: Exopterygota

Order : Homoptera

Family : Aphididae

Subfamily: Aphinidae

Genus : *Lipaphis*

Species: *Lipaphis erysimi* (Kalt.)

2.1.2. Distribution of mustard aphid

The mustard aphid, *L. erysimi* (Kalt.) is distributed worldwide (Martin 1983, Pradhan 1995). It is found in all tropical and subtropical countries (Scmutterer, 1978) and is recognized as a worldwide serious cruciferous pest (Atwal *et al.*, 1976).

2.1.3. Host range of mustard aphid

Jahan & Rahman (2011) conducted a study to know the diverse response on growth stages of mustard varieties to mustard aphids. Among ten mustard varieties, the maximum aphid population was recorded on Tori-7 at flowering stage but the population reached to the peak in BS-5 variety. Pod formation stage was more vulnerable for aphid infestation and increased population. Aphid infestation received higher at pod formation stage than flowering stage and consequently produced lower yield.

Sam & Pang (1999) observed that the population dynamics of alates and apterous of turnip aphid, *Lipaphis erysimi* (Kalt.) on five host vegetable varieties in the field were evaluated. The results showed that the average populations of apterous aphid on host vegetable varieties turnip, Chinese kale, mustard leaf, flowering cabbage and Chinese cabbage were 63. 425, 10. 041, 24. 928, 23. 323 and 114. 308 aphids/plant, respectively.

In temperate climate, many aphid species are host alternating and have a primary host, which is usually a woody plant and secondary hosts, which are generally herbaceous (Dixon 1982).

Lipaphis erysimi is well known as a serious pest of mustard, cauliflower, turnip, kohlrabi, radish, Chinese cabbage, rai, toria, Brussels sprout, broccoli, kale and rutabaga and a minor pest of bean, beat spinach, pea celery, onion, stock, cucumber and potato (Scmutterer 1978). Gosh (1985) reported that host plant range covering many families.

2.1.4. Seasonal abundance of mustard aphid and its predators

Bhadra & Parna (2010) found that the mustard aphid, *Lipaphis erysimi* (Kalt) is a serious pest of mustard in tropical regions in the world. The population dynamics of this species is considerably influenced by immigrant alate, which migrate to the mustard crop from the off-season shelter. Aphids reproduce at a higher rate in the early vegetative stage of mustard plants when the developmental period is shortest and production of winged morphs is lowest. The population reaches an asymptote when the crop is 70 days old. The species regulates its developmental period, fecundity and intrinsic rate of increase in response to developmental changes of the mustard plant and maintains its dispersal throughout the duration of the mustard crop. In succeeding generations on a mustard plant new born nymphs took increasingly longer to develop into adults and over the same period these adults produced decreasingly fewer numbers of offspring. In the inflorescence and fruiting stages of mustard plants a higher proportion of the nymphs developed into alatae.

Aphids are an important group of plant insect pests. They have a high biological potential with some of aphids species (Aphididae) having more than ten generations in one year (Iversen and Harding, 2007). Because of their direct (sucking) and indirect (transmission of viruses and honeydew secretion) damage on cultivated and wild-growing plants, the producers of plant food, ornamental plants and feed for livestock and control them in different ways.

Vekaria & Patel (2005) conducted an Experiment during rabi 1993-94 and 1994-95 revealed that the incidence of aphid commenced 6 weeks after sowing (WAS) i.e., the third week of December and reached the peak intensity (3.94 AI) at 14 weeks after sowing coinciding with second week of February during 1993-94, however, during 1994-95 aphid incidence commenced late (8 WAS), i.e. during last week of December and reached the peak intensity (3.08 AI) 13 WAS coinciding with first week of February. The aphid population exceed fluctuated above economic threshold level (ETL) between 11 and 14 WAS coinciding with the third week of January to second week of February. The predominant coccinellid predator *Coccinella septempunctata* was active between last week of January and last week of February with maximum population (5.52 and 3.07 beetles/plant) during third week of February in both the years.

Panda *et al*. (2000) conducted an experiment during the 1998-99 winter seasons to study the intensity and population fluctuation of *Lipaphis erysimi* on *Brassica juncea* in relation to the prevailing abiotic and biotic conditions. 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°C, maximum temperature between 24.9 and 29°C were found to be congenial for the proper development of aphid population. The natural enemies like *Menochilus sexmaculatus* influenced the aphid population during their activity period from January to February.

Nayak *et al.* (2000) studied during the Rabi season of 1996-97 to determine the seasonal abundance of the *L. erysimi* pest. The highest aphid population was recorded on the second week of January, when it reached 42.95, 22.95, 22.30, 17.35, 16.32 and 11.72 on Indian mustard, cabbage, cauliflower, knolkhol, radish and turnip respectively. Thereafter, the aphid numbers declined. Overall, the mean aphid population during the season was highest (10.59) on radish and lowest (6.97) on turnip.

2.1.5. Extent of damage and yield loss caused by mustard aphid

Shelly (2009) found that two aphid species, *Brevicoryne brassicae* L., and *Lipahis eyrsimi* Kalt. were observed as the most devastating pests. Populations of *B. brassicae* were more than that of *L. eyrsimi*. All the varieties evaluated were found susceptible and weekly population of both the species of aphids did not differ significantly from their appearance till maturity of the crop. Appearance of aphids at all the locations was not uniform. However, the highest population was recorded during last week of February to second week of March.

Sam & Pang (1999) observed that the population dynamics of alates and apterous of turnip aphid, *Lipaphis erysimi* (Kalt.) on five host vegetable varieties in the field were evaluated. The results showed that the average populations of apterous aphid on host vegetable varieties turnip, Chinese kale, mustard leaf, flowering cabbage and Chinese cabbage were 63. 425, 10. 041, 24. 928, 23. 323 and 114. 308 aphids/plant, respectively.

The mustard aphid *Lipaphis erysimi* (Kaltenbach) causes serious losses of yield in Mustard crops and reduces its marketable value. Increase in population beyond 9.45

aphids per plant; reduce the seed yield by 59.3 per cent with an economic injury level of 2.04 aphids/plants with an index of 0.98 and infestation 37.4 per cent (Singh & Malik, 1998).

The yield loss due to aphid infestation in mustard ranged from 87.16 to 98.16% (Anon., 1995). Greatest loss reported in yield only due to mustard aphid, (*Lipaphis eyrsimi* Kalt.) is 83% to rapeseed and mustard in India (Mandal *et al.*, 1994). Losses due to insect pests are estimated to be 70-80% in Pakistan. But in case of severe infestation in years of sporadic attack there may be no grain formation at all (Khattak *et al.* 2002).

The colonies of mustard aphids feed on the new shoots, inflorescence and underside of leaves. Loss in yield up to 91.3 % (Sharma and Kashyap, 1998) and oil contents up to 15 % (Verma and Singh, 1987).

The damage is caused by both nymphs and the adults, these are louse-like and pale greenish insects, is seen feeding in large numbers, often covering the entire surface of the flower buds, shoots, pods etc (Ahmed and Jalil, 1993). In case of severe aphid infestation, leaves become curled, plant fails to develop pods, the young pods when developed fail to become mature and cannot produce healthy seeds. As a result, plants loss their vigor and growth becomes stunted (Morzia and Huq, 1991).

Khan and Munir (1986) observed the effect of aphid infestation on seed yield and other characteristics of Raya. The number of pods per plant in the treated (506.25) and in un-treated (187.02) was found significantly different from each other.

2.2. Management of mustard aphid

The most frequently mentioned control methods are spraying the plants with insecticides (Parker *et al.*, 2006), the use of corresponding agro-technical measures and in a lower extent the use of biological control agents (Du *et al.*, 2004).

2.2.1. Role of chemical insecticides for the management of mustard aphid

Sarwar (2011) conducted a study to evaluate the effects of new insecticides like, Imidacloprid (Confidor 200 EC), Thiomethoxam (Actara 25 WG) and Acetamiprid (Megamos 20 SL) alongwith conventional insecticides such as, Chlorpyrifos (Lorsban 40 EC) and Dimethoate (Systoate 40 EC) belonging to Organophosphate group against aphids population. The study reflected that, newer insecticides were superior in reducing the population of aphids and yield enhancement as compared to conventional insecticides. The best results were achieved with the application of Imidacloprid by recording the lowest number of aphids (2.2 per plant) than obtained with Thiomethoxam and Acetamiprid (3.22 and 4.66, respectively). Other insecticides, viz., Chlorpyrifos and Dimethoate were also found to be effective in maintaining the aphids' population at lower levels per plant (16.2 and 17.5, respectively) over untreated control (227.7).

Amer (2010a) conducted an experiment with conventional and neonicotinoid insecticides to test their toxicity to cabbage aphid, *Brevicoryne brassicae* L. and turnip aphid, *Lipaphis erysimi* (Kalt). Insecticides were Actara 25WG @ 15g a.i/ha, Confidor 20SL @ 0.125 L. a.i/ha, Advantage 20EC @ 0.5 L. a.i/ha, Talstar10EC@ 0.0625 L. a.i/ha and Methamidophos 60SL @ 1.5L. a.i/ha. Seven days after application all the insecticides proved to be similarly toxic to aphids and statistically higher numbers of both aphid species were observed in untreated plots. The lowest numbers of aphids were observed in plots where Talstar was applied as compared to Advantage, Actara and Confidor. However, aphid numbers were too high even after three days of application particularly after first spray. Results of this study suggest that insecticides should not be applied at pod-filling stage to manage aphids.

Amer (2010b) studied the effectiveness of nine insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) on mustard as foliar spray. Studies revealed that seventh day of spray; imadacloprid 17.8 SL @ 0.0178% gave most effective control. On seventh day after spray, the order of effectiveness was imadacloprid 0.0178% > oxydemeton methyl 0.025% > monocrotophos 0.036% > dimethoate 0.03% > chloropyriphos 0.05% > malathion 0.05% > endosulfan 0.07% > cypermethrin 0.01% > neemarin, respectively.

Said (2005) also reported that after two weeks of spray of insecticides Karate was found best in suppressing of pest population (9.67 aphid per inch of inflorescence), followed by Actara, Ripcord, Bestox, Curacron, Lorsban, Thiodan, Methamidophos, Advantage and Sevin with reduction of aphid population to 14.44, 18.00, 19.78, 20.33,23.22, 24.78, 24.89, 34.11 and 49.11 per inch of inflorescence respectively. All of insecticides were found effective against aphids on canola crop compared to control (130.00 aphids per inch of inflorescence) at 5% level of significance.

Gami (2002) reported the results of 11 different insecticide treatments with methyl-o-demeton 0.025%, carbosulfan 0.04%, methyl parathion 2% dust @ 25kg/ha and monocrotophos 0.04% were found highly effective against mustard aphid, *Lipaphis erysimi* Kaltebach. Profenophos 0.05% and azadirachtin 0.00075% were found less effective against this pest.

Tong (2001) reported the toxicity baselines and efficacies of primicarb (Pirimor, imidacloprid (Provado), thiamethoxam (Actara) and lambda-cyhalothrin (Warrior) were bioassayed in the laboratory and tested in the field against mustard aphid, *Lipaphis erysimi* (Kalt). Results showed that the LC_{50} and LD_{50} of the four insecticides for apterous *L. erysimi* adults were comparable with those for other aphid species. Results from field trials showed that primicarb and lambda-cyhalothrin were the most effective among these insecticides, followed by imidacloprid. A field rate (25 gm a.i./ha) of thiamethoxam did not provide satisfactory control of *L. erysimi*, but higher field rate did (50 gm a.i./ha).

Gazi (2001) tested five organophosporus insecticides viz., phosphamdon, quinalphos, malathion, dimethoate and diazinon against mustard aphid, *Lipaphis erysimi* (Kalt) in the field and net house condition. All these insecticides significantly controlled mustard aphid. Quinalphos was comparatively more effective in controlling mustard aphid followed by phosphamidon. Diethoate, diazinon and malathion showed more or less response against the mustard aphid.

Khan and Akber (1999) stated that significantly high grain yield of 1.44, 1.35, 1.20, 1.05 kg /plot (3 x 5m size) was obtained in Tamaron 600 SL, Follidole 50EC, Ripcord and Nuvacron treated plots, respectively, compared to grain yield of 0.75 kg/plot obtained from untreated plot of the same size.

Lal (1992) tested the efficacy of various insecticides against *L. erysimi*, *Brevicoryne brassicae* and. calculated that endosulfan at 500g ai ha^{-1} gave the most effective control and provided 708.07kg seed ha^{-1}, compared to 72.08kg seed ha^{-1} from untreated plots. Cypermethrin and deltamethrin @10g ai ha^{-1} each gave good control of the pests. Malathion at 1000g ai ha^{-1} was found less effective.

Phadke (1990) studied that in Bangladesh and other areas of Indo-Pak subcontinent, foliar insecticides generally control insect pest of mustard. Other control methods like cultural, biological are not well known to farmers.

Bhuiyan (1989) conducted an experiment to find out the most effective insecticide (s) for the control of mustard aphid, *Lipaphis erysimi* Kaltenback (Homoptera : Aphididae) in the field. Eight different insecticides, namely, Marshal 20 EC, Dimecron 100 EC, Malathion 57 EC, Zolone 35 EC, Perfekthion 40 EC, Ripcord 10

EC, Diazinon 60 EC, and Elsan 50 EC were applied as general application covering the whole plants. The mortality data recorded 24 and 48 hours after insecticidal treatments were subjected to statistical analysis. Significant difference was observed among the treatments at 1% level of probability. The results indicated that Marshal 20 EC, Zolone 35 EC and Perfekthion 40 EC – 2 ml/l of water were most effective insecticides in reducing aphid population.

Thakur and Kashyap (1989) tested the toxicity and persistence of different compounds on final instar nymphs of mustard aphid (*L. erysimi*). They noted that malathion retained some toxicity 3 days after spraying on sarson leaves. In laboratory ingestion tests, % toxicity/ LC_{50} values to *Apis mellifera* were determined 0.0615.

Karishniah and Mohan (1983) conducted an experiment on mustard aphids and observed that mustard aphid population on cabbage was in considerable number after third spray in November. Quinalphos, methamidophos, chlorpyrifos (0.5kg ai/ha) monocrotophos (both 0.3 and 0.5 kg ai/ha), endosulfan (0.7 kg ai/ha) gave effective control and suppressed the population for over fortnight. Performance of monocrotophos at 0.3 kg ai/ha was equally good as that at 0.5 kg ai/ha phosphamidon. Phenthoate, methomyl, chlorfenvinphos, malathion, fenitrothion, trichlorfon, garlic oil, carbaryl and dicrotophos were also found ineffective.

Gandhale *et al.* (1983) tested endosulfan, quinalphos, fenitrothion, phosalone and malathion at 0.05% and formothion and thiometon at 0.02% for their effectiveness against the aphid on cabbage in field trials and reported that the highest mortality was caused by thiometon (77.28%), while malathion was least effective (62.48%). The mortalities caused by the remaining treatments ranged from 7.50 to 76.57%.

Ahmad (1970) studied systemic activity of four granular insecticides (phorate 10%, Temik 10%, diazinon 5% and Sevidol [8% carbaryl + 8% gamma-BHC]) for the control of mustard aphid, *Lipaphis erysimi* (Kalt). The granules were applied in the soil to one month old mustard plants transplanted in pots. Mortality counts were made 24 hours after release. Of the insecticides tested, phorate and Temik at 1 lb a.i./ac proved most effective. Temik had a quick knockdown effect as compared to phorate, as it gave 100% control within 24 hours, while with phorate 100% kill was obtained only after 72 hours. Diazinon at 4 lb a.i. /ac gave 83.3% kill after 72 hours. Sevidol proved ineffective as an aphidicide.

2.2.2. Role of ladybird beetle for the management of mustard aphid

Sarwar and Saqib (2010) conducted an experiment with seven-spotted ladybird beetle *Coccinella septempunctata* L., a natural enemy of aphids, had been reared on natural and alternative artificial foods. Both larvae and adults of *C. septempunctata* fed on aphid and artificial diet, the predator normally completed its development from egg to adulthood in 20.6 days on aphid prey, in contrast to 29.0 days, when fed on artificial diet. These results indicated that artificial diet containing important ingredients for adults and larvae of *C. septempunctata* can serve as substitute food for the coccinellids, and reproduction nevertheless can occur in the absence of preferred aphid prey. The present findings can best be utilized for effective mass production of coccinellids species intended for biological control of insect pests.

Pushpendra and Prakash (2010) found that feeding potential of seven spotted ladybeetle, *Coccinella septumpunctata* (Linn) was studied under laboratory conditions on mustard aphid, *Lipaphis erysimi* (Kaltenbach) and cotton aphid, *Aphis gossypii* (Glover). *C. septumpunctata* showed high feeding performance on mustard aphids *L. erysimi* than *A. gossypii*. The fourth instar larvae of *C. septumpunctata* consumed the highest number of aphids of *L. erysimi* and the hourly consumption was 6.50±0.80, 6.10±0.73 and 6.40±0.96 for first, second and third hours, respectively in unstarved condition, while in starved condition the hourly consumption was 11.20±0.91, 8.30±0.94 and 8.00±1.05 for first, second and third hours, respectively. The hourly consumption of fourth instar larvae *C. septumpunctata* on aphid, *A. gossypii* was 2.60±0.69, 2.20±0.78 and 2.00±0.66 for first, second and third hours, respectively in unstarved condition, while in starved condition, the hourly consumption was 3.30±0.67, 2.70±0.67 and 2.30±0.67 for first, second and third hours, respectively.

Shelley (2009) conducted an experiment was laid out with 12 treatments including control to find out the persistence of toxicity of insecticides in dust and wettable formulations on mustard crop. The results indicate that, both under field and laboratory conditions, Sumithion 40EC spray and Elsan 2% dust proved most effective. Sevin 50 WP spray proved ineffective. After 10 days of treatment all insecticides of dust and wettable formulations last their toxicity.

The ladybird beetle belongs to the family Coccinellidae of order Coleoptera. The members of the family are exclusively predator on aphids, mealybugs, scale-insects, whiteflies, thrips, leafhoppers, mites and other small soft bodied insect pests (Omkar and Pervez, 2000). It is known to prey on about 39 Arthropod species (Gautam, 1989). The family Coccinellidae comprises 5,200 described species worldwide (Hawkeswood 1987). Pushpendra (2010) have reported 31 species of Lady beetles.

Soni *et al.* (2004) conducted a laboratory experiment to determine the feeding potential of *C. septempunctata, Menochilus sexmaculatus, Cheilomenes sexmaculata*, and *Brumoides suturalis* on mustard aphid *L. erysimi* and they reported that the adult of *C. septempunctata* consumed more mustard aphids.

Singh *et al.* (2003) studied relative abundance of the effective natural enemies of mustard aphid *L. erysimi,* in farmers' fields; the *C. septempunctata* was the highest (41.97%) occurring species. All the natural enemies showed increasing trend till harvest of the crop, whereas, the coccinellids occupied a major share with maximum relative abundance of *C. septempunctata.*

Vandenberg (2000) reported that among the natural enemies' coccinellids are the best known beneficial predatory insects. Coccinellids are commonly known as ladybird, lady beetles or lady bugs. Lady bird belongs to the family Coccinellidae and order Coleoptera. About 6000 species of ladybird beetles found all over the world.

Rafi *et al*. (2005) reported that ladybird beetles generally considered as useful insects as many species feed on soft bodied insects like aphids, jassids, psyllids, whiteflies, scale insects, mealy bugs, insect eggs, small larvae and phytophagus mites which are injurious to agricultural crops and forest plantations.

The success of capturing prey of ladybird beetle depends on abiotic and biotic factor such as plant structure, species of aphid attacked, the predator, in its particular age, level of hunger and genetic characteristics, intra and inter specific competition. (Ferran, 1993).

Agarwala *et al.* (1988) reported that the predacious coccinellid beetles, commonly known as lady bird beetles are considered to be of great economic importance in the agro-ecosystem. They have been successfully employed in the bio-control to many injurious insects.

Kalra (1988) reported that, in the field mustard aphid population is naturally controlled to a large extent by its predator, *Coccinella septempunctata* and plays a vital role in lowering the population of mustard aphid in the field.

2.2.3. Effect of insecticides on predatory ladybird beetles during the management of mustard aphid

A research was carried by Sohail *et al.* (2008) to study the effect of different chemical pesticides on mustard aphid (*L. erysimi*) and their adverse effects on Ladybird beetle in field. The experiments were carried out with eight treatments, Actara (low) @ 5g/100 lit water, Actara (medium) @ 10g/100 lit water, Actara (high) @ 15g/100 lit water, Confidor (low) @ 80ml/100ml lit water, Confidor (medium) @100ml/100 lit water, Confidor (high) @ 120ml/100 lit water, Fastkil @ 200ml/100 liter of water with a control. Results showed that Fastkil was more toxic to the mustard aphid (*L. erysimi*) population followed by Actara. Fastkil was found most lethal for the ladybird beetle population followed by Confidor and Actara. The study recommends the use of Actara for the safe and effective control of mustard aphid (*L. erysimi*). Farmers should use Actara for the control of Aphids (*L. erysimi*) in the field as it is the least toxic to ladybird beetle population (Sohail *et al.*2008).

Youn *et al.* (2003) reported that some of the ladybird beetles are susceptible to chemical insecticides chlorpyrifos and pirmicarb at the recommended rates. Generally, the 1st and 2nd instars of ladybird beetles were very sensitive to thiamethoxam (aktara) and abamectin but these chemicals are very effective against aphids.

Mannan (2002) conducted an experiment with Malathion 57 EC and Diazinon 60 EC with different doses (1 ml, 2 ml, 3 ml/l water) were tested to evaluate the effect on mustard aphid and their toxicity on the predators and other beneficial insects of mustard aphid. Malathion was more effective then Diazinon for the control of aphids and it was less toxic to the predator and other beneficial insects. The lower dose of insecticides has less adverse effect on the predator and other beneficial insects then the higher dose.

Pradhan *et al.* (1995) observed that Malathion, Parathion, Diazinon, and Et- 4P2O7 were 44.0, 16.4, 16.3, and 6.3 times as toxic to *C. septempunctata* grubs as was Systox. Et-6P4O13 and Isodrin were less toxic than was Systox. With the adult beetles, Parathion, Malathion, and Et-6P4O13 were, respectively, 25.6, 9.5, and 8.9 times as toxic as was Systox. All other insecticides used showed a very low toxicity. Generally the adults were more resistant than the grubs to the insecticides tested. Organophosphorus insecticides were generally very toxic to mustard aphid. Parathion, Malathion, and Diazinon were more toxic to the grubs of *C. septempunctata* than to *L. erysimi*. Systox, Pestox, Et-6P4O13, and the insecticides of the chlorinated hydrocarbon group had a somewhat greater safety margin for *C. septempunctata* grubs. *C. septempunctata* adults were more resistant than aphids to all the insecticides, but the safety margin was rather low for parathion and malathion.

Some of the insecticides are fast killing all the life stages of coccinellids that feed on the treated aphids. Carbaryl and phosmet are slow acting insecticides that cause the greatest mortality. Methomyl did not cause 100% mortality of ladybird beetle feeding on insecticides treated aphids (Hurej and Dutcher, 1994).

Sing and Sircar (1983) evaluated the toxicity of insecticides against eight species of aphid and predacious *Coccinella septempunctata*. According to them the most toxic compounds against *Aphis cracivora, A. gossypii, B. brassicae, Dactyesotus earthami, L. erysimi, Myxus persicae and Rhopalophum maidis* were Phorate, Dimethoate and Carbaryl. Some evidence of the resistance to insecticides was found and susceptibility varied with food plants. Endosulfan, Lindane and Phidan were effective against aphid and relatively safe against *C. septempunctata*.

Tewary and Moorthy (1983) conducted field plot tests in to determine the effectiveness of spray of 10 insecticides for control of *Aphis gossypii*. They noted their effects on predator *Menochilus sexmaculatus* and calculated that endosulfan at 700g was considered to be the best treatment followed by phosphamidon, metasystox and dimethoate at 500, 700 & 700g respectively. Cypermethrin, fenvalerate, permethrin, deltamethrin, malathion and carbaryl were less toxic to aphid than the previous four treatments but gave high mortality of the coccinellids.

2.2.4. Integrated effect of insecticides and botanical products in controlling mustard aphid

A research was carried out by Sultana (2009) on the management on mustard aphid (*Lipaphis erysimi)* using Neem Kernel extract with two chemical insecticides, Aktara 25 WG and Diazinon 60 EC. Among the treatments on an average Aktara reduced the highest aphid population (92%) with the highest BCR (4.20) followed by Diazinon (89%) and Neem Kernel extract + Jet powder (65%). Diazinon 60EC gave the second highest BCR (3.83) followed by Jet powder (3.62) and Neem kernel extract + Jet powder (3.07). The highest yield (1568 kg ha^{-1}) was also found in Aktara treated plot which was statistically similar to Diazinon treated plot (1485 kg ha^{-1}) and the lowest yield (840 kg ha^{-1}) was found in control plot.

Farag (2007) evaluated four insecticides, Thiomethoxam (Actara 25% WG), Imidacloprid (Confidor 35% SC), Natural oil of Jojoba plant (Nat-1), formulated as 96% FC and Pirimicarb (Aphox 50% DG) against the parasitoid wasp, and its host aphid. Actara and Aphox scored the highest effectiveness against the parasitoid wasp followed by Confidor, then Nat-1.

2.2.5. Use of pitfall trap as monitoring devise during the management insect pests crops

Mark (2011) reported that pitfall trapping is one of the most widely used arthropod sampling techniques. However, relative species abundance in pitfall trap catches differs from that found using quadrat samples. This difference, here termed bias, reflects the fact that pitfall trap catch is influenced not only by abundance but also by other factors, including activity, which may be linked to body size.

David (2010) reported that, pitfall trapping is commonly used to sample epigaeic invertebrates throughout the world. However, this technique can be ineffective for capturing some species, whilst capturing high numbers of non-target invertebrates. Four types of pitfall traps were used in two separate sampling regimes: baited kill trap versus non-baited kill trap, and chambered live trap versus non-chambered live trap. Results show all four types of traps sampled different components of the invertebrate community. Baited kill traps caught extremely high numbers of some groups, particularly Diptera and Coleoptera, whereas non-baited kill traps caught far fewer individuals of these groups. Both types of live capture traps caught few individuals. Although baiting did not increase catches.

Pitfall traps intercept ground-dwelling animals, usually without the use of an attractant, and are used to provide relative density estimates (Southwood and Plowing or other tillage practices result in the greatest negative impact on soil mite populations (Koehler, 1997), causing up to 50 percent reductions in population densities directly after tillage (Hülsmann and Wolters, 1998). In general, undisturbed soil ecosystems have greater species richness of mites than do agricultural soils (Barbercheck *et al*., 2009).

Henderson, 2000; Ausden and Drake, 2006). The catches indicate arthropod activity rather than absolute density, and results are influenced by environmental conditions. Thomas *et al.* (2006) also found that densities in adjacent treatments in a single field trial are not independent of each other because of significant movement between treatments, especially if there is a vegetation density gradient.

For a complete picture of ant's composition in a habitat, a combination of pitfall traps with other methods, such as Winkler bags, direct counts, and hand searching might be needed to catch the rare species and species from other strata (Agosti and Alonso, 2000).

Hand search and litter extraction can reveal those cryptic ants, and arboreal nesting species, and sparsely distributed species, which are likely under sampled by pitfall traps (Majer, 1997).

Barber (1991) reported that pitfall traps continue to be among the most widely employed sampling methods for ground dwelling arthropods. Consisting of cups sunk into the ground flush with the surface, pitfall traps are inexpensive, easy to use and operate round the- clock, resulting in large, species-rich samples (Clark & Blom 1992). A variety of liquids are employed to retain, kill and preserve the arthropods. Solutions of formalin and water were once common, but have been largely abandoned because of health hazards (Van den Berghe 1992). Pure water is an alternative (Waage 1985), but mixtures with ethanol, glycerin, ethylene glycol or brine are often preferred because their conservation attributes are presumably better (Holopainen 1992; Teichmann 1994). The use of different preservatives also affects sampling efficiency and thereby complicates comparisons between studies.

In measuring and monitoring biodiversity and conducting inventory of arthropods, one important aspect is to establish standard sampling methods that can obtain unbiased results that are comparable to other studies. Ants have been the subject of numerous ecological studies and have been sampled by various methods including pitfall traps, bait traps, litter sampling, beating, sweeping, and hand picking (Andersen, 1991; Romero and Jaffe, 1989).

All of existing ant sampling methods has their advantages as well as disadvantages in terms of cost, convenience, quality of samples, and representation of the ant species richness, relative abundance, and repeatability. Leaf litter ants are commonly sampled by pitfall and bait traps. Pitfall traps are easy to use and can be operated continuously during day and night over extended periods of time with little attention required. It provides a reasonably good estimation of species richness and relative abundance, but has potential defects (Olson, 1991).

CHAPTER III

MATERIALS AND METHODS

The present experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2010 to February 2011 to explore the efficiency of chemical insecticides on the reduction of infestation level of mustard aphids and the impact of those insecticides on predatory ladybird beetle and other beneficial insects on mustard. The details of different experimental materials and methodologies followed during the course of the investigation are described under the following sub-headings:

3.1. Location and duration of the experimental site

The research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207 (Plate 1) during the *Rabi* season of 2010-11. (from November 2010 to February 2011).

3.2. Soil of the experimental site

The soil of the experimental field belongs to the Tejgaon series under the Agro ecological Zone, Madhupur Tract (AEZ- 28) and the general soil type is Shallow Red Brown Terrace Soils. It was medium high land, fertile, well drained, fairly leveled and slightly acidic with pH varying from 5.8 to 6.5, CEC 25-28 (Haider *et al.*, 1991).

3.3. Climate

The experimental area has sub tropical climate characterized by heavy rainfall during May to September and scantly rainfall during rest of the year. The experiment was carried out during rabi season of 2010-2011. Temperature during the cropping period ranged from 13.32^0 to 24.12^0 C.

Plate 1. The experimental field of mustard laid out in the farm of SAU, Dhaka

3.4. Preparation of the field

The plot selected for the experiment was opened by power tiller driven rotovator, afterwards the land was ploughed and cross-ploughed followed by laddering to obtain a good tilth. The corners of the field were spaded, weeds and stubbles were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. The target land was leveled and the experimental plot was divided into 21 equal plots with a plot size of 2.0 m x 1.5 m and plot to plot distance 0.5 m; block to block distance 1.0 meter.

3.5. Application of fertilizers

Recommended doses of N, P, Zn and B (30 kg N from urea, 30 kg P from TSP and 2 kg Zn from ZnO respectively) were applied. The whole amount of TSP and ZnO half of the urea fertilizer were applied as basal dose during final land preparation. The remaining half of urea was top dressed after 20-22 days of germination.

3.6. Design of the experiment and layout

The experiment was laid out in a Randomized Complete Block Design with three replications. The total numbers of plots were 18 for 6 treatments, each measuring 2.5 m × 1.5 m (3.75 m^2). The adjacent block and neighboring plots were separated by 1.0 m and 0.5 m, respectively.

3.7. Treatments

Five insecticides from three groups and one untreated control were evaluated in this study applied against mustard aphid, where each insecticide was treated as individual treatment to determine their efficiency. The group wise insecticides with their specific dose applied as treatment were given below:

Treatment	Insecticides ®	Dose	Insecticide group
T_1	Malathion 57EC	@ 2 ml//l of water	Organophosphate
T_2	Sevin 85WP	@ 4 g/l of water	Organocarbamate
T_3	Marshal 20EC	@ 3 ml//l of water	Organocarbamate
T_4	Aktara 25 WG	@ 0.5 g/l of water	Thiamethoxam
T_5	Ripcord 10EC	@ 3 ml//l of water	Cypermethrin
T_6	Untreated control	No control measure	

3.8. Detail procedure of the study

The detail procedure considering the materials used and methodology followed in the study were furnished in below:

3.8.1. Materials

The mustard variety Tori-7 was cultivated in the designed field to investigate the present study according to the objectives mentioned earlier.

3.8.2. Seed sowing

Seeds of the Tori-7 variety of mustard collected from BADC were sown in the selected field on 17th November 2010 in lines following the recommended row to row distance of 30 cm. After germination the seedlings (Plate 2) were sprinkled with water.

Plate 2. Seedlings of mustard in the experimental plot

3.8.3. Intercultural operation

The weeds found in the mustard field were cleaned and removed manually. The thinning of the mustard seedlings were also done as required during the growing season and care was taken to maintain uniform plant population per plot. Three times flood irrigation was given in the field at vegetative stage.

3.8.4. Application of the treatments

The selected treatments comprising different insecticides with their assigned doses were started to apply in the respective plots when the aphids were first appeared in the mustard field. The first appearance or incidence of aphids was determined by visit and daily direct visual observation of mustard plants. Therefore, considering the first appearance of the aphids in the field, treatment applications were started at 45 days after sowing (DAS) of the mustard seeds. The treatments were applied at 7 days interval and continued up to 66 DAS when most of the siliqua were formed. In case of untreated control, only fresh water was sprayed.

3.8.5. Setting up of pitfall trap

Three pitfall traps (Plate 3) were set up in each plot, of which one in the middle and other two in two opposite corners of the field. The traps were plastic cups with 10 cm height and an opening of 5 cm. The traps were partially filled with water mixed with detergent. The traps were carefully rooted in the field and the opening was leveled to the ground.

Plate 3. Pitfall trap for capturing soil inhabiting insects in the mustard field

3.9. Data collection and calculation

Eight plants per plot were selected randomly and tagged for data collection. Data collection was started at 45 DAS. All data were collected before the application of treatment. After the completion of data collection, insecticides were sprayed as schedule. The data were collected on aphid population, level of pod infestation, pod deformation, 1000 seed weight, yield of mustard, incidence of ladybird beetle larvae and adult by direct visual count and pitfall trap methods, and incidence of ant population by pitfall trap method throughout the growing period of mustard in the field.

3.9.1. Data on aphid population

The number of aphid population on 8 randomly selected plants from each plot was counted at 45, 52 and 59 DAS. The top 8 cm apical twigs and or inflorescence of selected plant were cut and put into the polythene bags separately, and then brought to the laboratory of the Department of Entomology. The aphids were removed from the infested twig and or inflorescence with the help of a soft camel hail brush and placed on a piece of white paper. The numbers of aphids for each plant were counted visually as well as with the help of a magnifying glass and then recorded the number of each treatment. The percent reduction of aphid population from insecticide treated plot over the untreated control was calculated using the following formula (Khosla, 1997):

$$\text{\% aphid population reduction over control} = \frac{\text{Mean of untreated plot - Mean of treated plot}}{\text{Mean of treated plot}} \times 100$$

3.9.2. Data on pod infestation

The total numbers of pods (Plate 4), number of aphid infested pods (Plate 5) and number of deformed pods of the randomly selected 8 standing mustard plants for each plot were counted and recorded for each data recording time. The percent pod infestation by aphid and percent pod deformation were calculated separately using the data on the total number of pods, number of aphid infested pods and number of deformed pods for each treatment. The percent increase of pod formation, percent reduction of pod infestation and percent reduction of pod deformation from insecticide treated plots over untreated control were also calculated using the following formula:

$$\text{\% increase of pod formation over control} = \frac{\text{Mean of untreated plot - Mean of treated plot}}{\text{Mean value of treated plot}} \times 100$$

$$\text{\% reduction of pod infestation over control} = \frac{\text{Mean of untreated plot - Mean of treated plot}}{\text{Mean value of treated plot}} \times 100$$

$$\text{\% reduction of pod deformation over control} = \frac{\text{Mean of untreated plot - Mean of treated plot}}{\text{Mean value of treated plot}} \times 100$$

Plate 4. Uninfested healthy pods of mustard in the field

Plate 5. Severely aphid infested and deformed pods of mustard

3.9.3. Harvesting and data on 1000 seed weight and yield of mustard

The crop was harvested at full maturity, from 22 - 24 February, 2011. Seeds from each plot were collected, cleaned and bagged separately for the purpose of studying yield characteristics. From the collected seeds for each treatment, the 1000 seed weights and yield per plot were measured and recorded. The yield of mustard in kg per plot then converted into yield in kg ha^{-1}. The percent increase of 1000 seed weight and yield of mustard seeds over control were calculated using the following formula (Kholsa, 1997):

$$\text{\% increase of 1000 seed weight over control} = \frac{\text{Mean of untreated plot - Mean of treated plot}}{\text{Mean value of treated plot}} \times 100$$

$$\text{\% increase of seed yield over control} = \frac{\text{Mean of untreated plot - Mean of treated plot}}{\text{Mean value of treated plot}} \times 100$$

3.10. Data on ladybird beetle and other beneficial insects

Larvae and adults of ladybird beetles were found as the major beneficial insects in the mustard field. Ants were also found as soil dwelling insects in the mustard field. The data on incidence of larvae and adults of lady birds were counted through direct visual observation and pitfall trap methods from the field and then recorded. Using pitfall trap the incidences of ants found in the field were counted.

3.10.1. Incidence of larvae and adults of ladybird beetle by visual count

The numbers of adults and larvae of ladybird beetles were counted from randomly selected 8 standing mustard plants from each plot through direct visual observation in the afternoon at 7 days interval for each data recording time. The percent reductions of the larvae and adults of ladybird beetles from insecticide treated plots over control were calculated using the following formula:

$$\text{\% reduction of larva/adult lady beetle over control} = \frac{\text{Mean of untreated plot - Mean of treated plot}}{\text{Mean value of treated plot}} \times 100$$

3.10.2. Trapping of larvae and adults of ladybird beetle by pitfall trap

The numbers of adults and larvae of ladybird beetles were also counted from each plot through pitfall trap method at 7 days interval for each data recording time. The percent reductions of the larvae and adults of ladybird beetles from insecticide treated plots over control were also calculated using formula as mentioned above.

3.10.3. Recording of ants and other soil dwelling insects using pitfall trap

The numbers of ants and other soil dwelling insects were counted from each plot by pitfall trap method at 7 days interval. The percent reductions of ants and other soil dwelling insects from insecticide treated plots over control were also calculated using formula as mentioned above.

3.11. Data analysis

The data collected on different parameters were analyzed using MSTAT-C computer software package and means for each parameter were separated by DMRT to determine the significant variations among treatment means at 5% level of significance.

CHAPTER IV

RESULTS AND DISSCUSSION

The study was conducted in the experimental field of Sher-e-bangla Agricultural University, Dhaka during Rabi season of 2010-11 to find out the impact of different insecticides on the infestation level of aphid and its predatory ladybird beetle as well as other beneficial insects on mustard. The results on different parameters of the study have been interpreted and discussed under the following sub-headings:

4.1. Effect of insecticides on the incidence of aphid population

Statistically significant variations were observed among the results of different management practices in terms of number of aphid population in different Days After Sowing (DAS) of mustard seeds. In case of 45 DAS, the highest aphid population (92.33 aphid/inflorescence) was recorded in untreated control plot (T_6), which was statistically similar to that of T_2 (88.00 aphid/inflorescence) comprising Organocarbamate insecticide, i.e., spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval and T_3 (80.00 aphid/inflorescence) treated plot (Table 1). On the other hand, the lowest aphid population (75.67 aphid/inflorescence) was recorded in T_5 comprising Cypermethrin insecticide, i.e., spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval followed by T_4 (77.67 aphid/inflorescence) comprising Thiomethoxam, i.e., spraying of Aktara 25 WG @ 0.5 ml/l of water at 7 days interval followed by T_1 (78.00) comprised of spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval. In case 52 DAS, the highest aphid population (109.7 aphid/inflorescence) was also recorded in control plot (T_6) which was statistically different from all other treatments. It was followed by T_2 (74.00 aphid/inflorescence) and T_1 (49.00 aphid/inflorescence). On the other hand, the lowest aphid population (26.00 aphid/inflorescence) was also recorded in T_5 followed by T_4 (36.00 aphid/inflorescence) and T_3 (39.33 aphid/inflorescence) treated plots. In case of 59

DAS, more or less similar trend was also observed among different management practices in terms of aphid population by number (Table 1).

Considering the mean aphid population, the highest aphid population (102.7 aphid/inflorescence) was recorded in control plot followed by T_2 (76.78 aphid/inflorescence) and T_1 (51.67 aphid/inflorescence). On the other hand, the lowest aphid population (39.00 aphid/inflorescence) was recorded in T_5 followed by T_3 (44.67 aphid/inflorescence) and T_4 (47.33 aphid/inflorescence) treated plot. Similarly, in case of percent aphid population reduction over control, the highest percent of aphid population reduction (163.33%) was observed in T_5 followed by T_3 (129.91%) and T_4 (116.99%) treated plot. On the other hand, the lowest percent of aphid population reduction over control was observed in T_2 (33.76%) followed by T_1 (98.76%) treated plot.

Table 1 Effect of different insecticides on the incidence of aphid population on mustard during Rabi season of 2010-2011

Treatment	Aphid population (No./Inflorescence*)				% reduction of aphid population over control
	45 DAS	52 DAS	59 DAS	Mean	
T_1	78.00 bc	49.00 c	28.00 c	51.67 c	98.76
T_2	88.00 abc	74.00 b	68.33 b	76.78 b	33.76
T_3	80.00 abc	39.33 cd	22.67 cd	44.67 c	129.91
T_4	77.67 c	36.67 cd	19.67 cd	47.33 c	116.99
T_5	75.67 c	26.00 d	15.33 d	39.00 c	163.33
T_6	92.33 a	109.70 a	106.00 a	102.70 a	-
LSD $_{(0.05)}$	14.24	16.23	10.23	13.39	-
CV (%)	9.60	14.34	10.91	8.57	-

*Data were recorded from 8 top inch length of mustard inflorescence

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above findings it was revealed that among five insecticide treatments applied against mustard aphid, the T_5 comprising Cypermethrin based insecticide that is spraying of Ripcord 10 EC @ 3 ml/ l of water at 7 days interval performed as the best treatment in reducing the highest aphid population by number (163.33%) over control followed by T_3 (129.91%) comprising Organocarbamate based insecticide that is spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval and T_4 (116.99%) comprising Thiomethoxam based insecticide that is spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval. On the other hand, T_2 comprising Organocarbamte insecticide that is Sevin 85 WP @ 4 g/l of water sprayed at 7 days interval showed the least performance (33.76%) in reducing aphid population followed by T_1 (98.76%) comprising Organophosphate based insecticide that is spraying of Malathion 57 EC @ 2 ml/ l of water at 7 days interval. As a result, the trend of efficiency among the five insecticides including one untreated control in terms of aphid population reduction ranking was T_5 (Ripcord 10EC) > T_3 (Marshal 20EC) > T_4 (Aktara 25 WG) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_6 (Untreated control). More or less similar findings were also observed by several researchers. Sarwar (2011) reported that among some new insecticides like Imidacloprid (Confidor 200 EC), Thiomethoxam (Actara 25 WG) and Acetamiprid (Megamos 20 SL) alongwith conventional insecticides such as, Chlorpyrifos (Lorsban 40 EC) and Dimethoate (Systoate 40 EC) belonging to Organophosphate group gave the best results with the application of Imidacloprid by recording the lowest number of aphids (2.2 per plant) than obtained with Thiomethoxam and Acetamiprid (3.22 and 4.66, respectively). Other insecticides, viz., Chlorpyrifos and Dimethoate were also found to be effective in maintaining the aphids' population at lower levels per plant (16.2 and 17.5, respectively) over untreated control (227.7). Amer (2010b) reported that seventh day of spray; Imadacloprid 17.8 SL @ 0.0178% gave most effective control. Said (2005) also reported that after two weeks of spray of insecticides Karate was found effective in suppressing of pest population (9.67 aphid per inch of inflorescence), followed by Actara, Ripcord, Bestox, Curacron, Lorsban, Thiodan, Methamidophos, Advantage and Sevin with reduction of aphid population to 14.44, 18.00, 19.78, 20.33,23.22, 24.78, 24.89, 34.11 and 49.11 per inch of inflorescence, respectively.

4.2. Effect of insecticides on mustard pod infestation

Significant variations were observed among different insecticidal treatments in terms of pod formation, pod infestation and pod deformation due to aphid infestation on mustard (Table 2 to Table 4).

4.2.1. Effect of insecticide on pod formation

Statistically significant variation was observed among the results of different management practices in terms of total pod formation at different DAS during the management of mustard. In case of 52 DAS, the highest number of pod formation (139.00 pod/plant) was recorded in T_5 composed of spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, which was statistically similar with T_4 (136.70 pod/plant) composed of spraying of Aktara 25 WG @ 0.5 ml/l of water at 7 days interval and T_1 (131.70 pod/plant) treated plot (Table 2). On the other hand, the lowest number of pod formation (110.30 pod/plant) was recorded in T_6 comprised of untreated control plot and followed by T_3 (126.30 pod/plant) comprised of spraying of Marshal @ 3ml/l of water at 7 days interval and followed by T_2 (129.7 pod/plant) comprised of spraying Sevin 85 WP @ 4 g/l of water at 7 days interval. In case 59 DAS, the highest pod number (141.70 pod/plant) was recorded in T_4 which was statistically different from all other treatment. This was followed by T_5 (137.30 pod/plant) and T_1 (134.00 pod/plant) treated plot. On the other hand, the lowest number of pod (122.3 pod/plant) was recorded in untreated control plot followed by T_3 (128 pod/plant) and T_2 (133.33 pod/plant) treated plot (Table 2). In case of 65

DAS, more or less similar trends were observed among different management practice in terms of number of pod/plant (Table 2).

Considering the mean number of pod formation per plant, the highest number of pod (148.8) was recorded in T_4 followed by T_5 (145.9) and T_1 (134.7). On the other hand, the lowest aphid population (123.2) was recorded in control plot followed by T_3 (131.4) and T_2 (132.9). The percent increase of pod formation over control indicate that the highest percent of pod increase (17.20%) was recorded in T_4 followed by T_5 (15.55%) and T_1 (8.53%) treated plot. On the other hand, the lowest percent of pod increase over control (6.24%) was recorded in T_3 followed by T_2 (7.29%).

Table 2 Effect of different insecticides on the pod formation during the management of mustard aphid in the field

Treatment	Pod formation (No./plant)				% increase of pod number over control
	52 DAS	59 DAS	65 DAS	Mean	
T_1	131.7 a	134.0 abc	140.7 abc	134.7 bc	8.53
T_2	129.7 ab	133.3 abc	135.7 abc	132.9 cd	7.29
T_3	126.3 ab	128.0 abc	141.3 ab	131.4 cd	6.24
T_4	136.7 a	141.7 a	142.3 ab	148.8 a	17.20
T_5	139.0 a	137.3 ab	147.3 a	145.9 ab	15.55
T_6	110.3 b	122.3 c	126.7 c	123.2 d	-
LSD $_{(0.05)}$	19.45	13.28	13.55	11.32	-
CV (%)	7.61	5.05	4.92	4.67	-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that among five insecticide treatments applied against mustard aphid, the T_4 comprised of spraying of Aktara 25 WG @ 0.5 g/l water was the most effective insecticide in increasing the highest percent pod formation

(17.20%) over control followed by Ripcord, Malathion, Sevin, whereas Marshal 20EC showed the least performance in pod formation (6.24%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of increasing the pod formation by number was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_3 (Marshal 20EC) > T_6 (Untreated control). About similar study was also carried out by Sultana (2009) on the management on mustard aphid (*Lipaphis erysimi)* using Neem Kernel extract with two chemical insecticides Aktara 25 WG and Diazinon 60 EC. Among the treatments on an average Aktara reduced the highest aphid population (92%) with the highest BCR (4.20) followed by Diazinon (89%) and Neem Kernel extract + Jet powder (65%).

4.2.2 Effect of insecticides on pod infestation

Statistically significant variation was observed among the treatments in terms of percent pod infestation at different DAS of mustard seed during the management of mustard aphid. In case of 52 DAS, the highest percent of infested pod (28.67%) was recorded in control plot (T_6), which was statistically different from all other treatment followed by T_2 (17.33%) comprised of spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval and T_3 (14.33%) comprised of spraying of Marshal @ 3 ml /l of water at 7 days interval (Table 3). On the other hand, the lowest percent of infested pod by number (11.00%) was recorded in T_5 comprised of spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval and followed by T_4 (11.33%) comprised of spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval and T_1 (13.67%) comprised of spraying of Malathion 57 EC @ 3 ml/l of water at 7 days interval. In case 59 DAS, the highest percent of infested pod by number (24.67%) was recorded in untreated control plot which was statistically different from all other treatment followed by T_2 (19.00%) and T_3 (14.33%). On the other hand, the lowest number of infested pod (9.03%) was recorded in T_4 followed by T_5 (9.67 %) and T_1 (13.00 %). In case of 59 DAS, more or less similar trends were observed among different treatments in terms of pod infestation in the field (Table 3).

Considering the mean population of pod infestation, the highest percent of infested pod (23.45 %) was recorded in control plot followed by T_2 (17.67 %) and T_1 (12.78 %) treated plot. On the other hand, the lowest percent of infested pod by number (9.03 %) was recorded in T_4 followed by T_5 (10.00 %) and T_3 (12.56 %).

Similarly, in case of percent reduction of infested pod over control, the highest reduction (160.46%) was recorded in T_4 followed by T_5 (134.50) and T_3 (86.70). On the other hand the lowest reduction (32.71) over control was recorded in T_2 followed by T_1 (83.48%).

Table 3 Effect of different insecticides on the pod infestation during the management of mustard aphid in the field

Treatment	Pod infestation (%) by number	% reduction of pod

	52 DAS	59 DAS	66 DAS	Mean	infestation over control
T_1	13.67 b	13.00 cd	11.67 b	12.78 c	83.48
T_2	17.33 b	19.00 b	16.67 a	17.67 b	32.71
T_3	14.33 b	14.33 c	9.00 bc	12.56 c	86.70
T_4	11.33 b	9.00 e	6.67 c	9.03 d	160.46
T_5	11.00 b	9.67 de	9.33 bc	10.00 cd	134.5
T_6	28.67 a	24.67 a	19.33 a	23.45 a	-
LSD $_{(0.05)}$	6.17	3.44	3.24	3.42	-
CV (%)	17.63	10.61	12.31	13.24	-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above findings it was revealed that T_4 comprised of spraying of Aktara 25 WG @ 0.5 g/l water performed as the most effective insecticide in reducing the highest percent of pod infestation (160.46%) over control followed by Ripcord, Marshal, Malathion, whereas Sevin 85 WP showed the least performance in reducing the pod infestation (32.71%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of reducing the pod infestation by number was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_3 (Marshal 20EC) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_6 (Untreated control). About similar results were also observed by Islam (1991) and Sultana (2009).

4.2.3 Effect of insecticides on pod deformation

Statistically significant variation was observed among the results of different treatments in terms of pod deformation at different DAS of mustard seed during the management of mustard (Table 4). In case of 52 DAS, the highest percent of deformed pod by number (11.33 %) was recorded in untreated control (T_6), which was statistically different from all other treatment followed by T_3 (8.33 %) comprised of spraying of Marshal @ 3 ml/Liter of water at 7 days interval and T_2 (8.00) comprised of spraying of Sevin 85 WP @ 4 g/ l of water at 7 days interval (Table 4). On the other hand, the lowest percent of pod deformation (5.00 %) was recorded in T_4 comprised of spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval and followed by T_5 (6.00 %) comprised of spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval and T_1 (8.00 %) comprised of spraying of Malathion 57 EC @ 3 ml/l of water at 7 days interval. In case 59 DAS, the highest percent of deformed pod (11.00 %) was recorded in control plot (T_6) which was statistically different from all other treatment followed by T_2 (10.33 %) and T_3 (8.33 %). On the other hand, the lowest percent of deformed pod (4.67 pod/plant) was recorded in T_4 treated plot followed by T_5 (6.00 %) and T_1 (8.00 %). In case of 59 DAS, more or less similar trends were observed among different management practice in terms of percent pod deformation by number in the field (Table 4).

Considering the mean of deformed pod per plant the highest number of deformed pod (11.67 %) was recorded in untreated control followed by T_2 (9.87 %) and T_3 (7.67 %) presented in Table 4. On the other hand the lowest number of deformed pod (4.77 %) was recorded in T_4 followed by T_5 (5.47 %) and T_1 (7.33%) treated plots. Similarly, in case of percent reduction of pod deformation over control, the highest percent reduction (144.29%) was recorded in T_4 followed by T_5 (114.24%) and T_1 (59.14%).

On the other hand, the lowest percent reduction of pod deformation over control (18.03%) was recorded in T_3 followed by T_1 (52.15%).

Table 4 Effect of different insecticides on the pod deformation during the management of mustard aphid in the field

Treatments	Deformed pod (%) by number				% reduction of deformed pod over control
	52 DAS	59 DAS	65 DAS	Mean	
T_1	8.00 bc	8.00 bc	6.00 bcd	7.33 c	59.14
T_2	8.00 bc	10.33 a	7.33 ab	9.87 b	18.03
T_3	8.33 bc	8.33 bc	6.33 abc	7.67 c	52.15
T_4	5.00 c	4.67 d	4.67 cd	4.77 d	144.29
T_5	6.00 c	6.00 cd	4.33 d	5.47 d	114.24
T_6	11.33 a	11.00 a	13.67 a	11.67 a	-
LSD $_{(0.05)}$	3.25	3.15	1.632	1.43	-
CV (%)	17.01	18.24	12.80	10.15	-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that among five treatment, the T_4 comprised of spraying of Aktara 25 WG @ 0.5 g/l water performed as the most effective insecticide in reducing the highest percent of pod deformation (144.29%) over control followed by Ripcord, Malathion, Marshal, whereas Sevin 85 WP showed the least performance in reducing the pod deformation (18.03%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of reducing the pod deformation by number was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_6 (Untreated control). About similar results were also observed by Islam (1991) and Sultana (2009).

4.3 Effect of insecticides on the yield attribute and yield of mustard

Statistically significant variation was observed among the results obtained from different management practices in terms of yield attribute and yield of mustard during the management of mustard aphid (Table 5 and Table 6).

4.3.1 Effect of insecticides on 1000 seed weight

Statistically significant variation was observed among the results of different treatments in terms of 1000 seed weight during the management of mustard aphid. The highest 1000 seed weight (2.93 g) was recorded in T_4, which was statistically different from all other treatment followed by T_5 (2.84 g) and T_1 (2.75 g) (Table 5). On the other hand, the lowest 1000 seed weight (2.05 g) was recorded in untreated control (T_6) comprised of untreated control followed by T_2 (2.10 gm) and T_3 (2.76 g). Considering the percentage of 1000 seed weight increased over control, the highest present increase (30.00%) over control was recorded in T_4 followed by T_5 (27.78%) and T_3 (23.02%). On the other hand, the lowest increase (2.23) over control was recorded in T_1 followed by T_2 (25.42 %) over control (Table 5).

Table 5 Effect of different insecticides on 1000 seed weight of mustard during the management of mustard aphid in the field

Treatment	1000 seed wt (g)	% increase of 1000 seed weight over control
T_1	2.753 c	25.42
T_2	2.10 e	2.23
T_3	2.66 d	23.02
T_4	2.93 a	30.00
T_5	2.84 b	27.78
T_6	2.05 ef	-
LSD $_{(0.05)}$	0.063	-
CV (%)	1.016	-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above findings it was revealed that among five insecticides, T_4 comprising Aktara 25 WG @ 0.5 g/litre water performed as the most effective insecticide in increasing the highest percent of seed weight (30.00%) over control followed by Ripcord, Malathion, Marshal, whereas Sevin 85 WP showed the least performance in increasing 1000 seed weight (2.23%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of increasing 1000 seed weight was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_6 (Untreated control).

4.3.2 Effect of insecticides on the yield of mustard

Statistically significant variation was observed among the results of different management practices against mustard aphid in terms of yield. The highest yield (778.9 kg/ha) was recorded in T_4, which was statistically different from all other treatment followed by T_5 (727.8 kg/ha) and T_3 (706.7 kg/ha) (Table 6). On the other hand, the lowest yield (594.4 kg/ha) was recorded in T_6 comprised of untreated control, followed by T_2 (676.7 kg/ha) and T_1 (701.1 kg/ha).

Considering the percent yield increased over control, the highest percent of yield increase (23.68%) over control was recorded in T_4 followed by T_5 (18.32%) and T_3 (15.89%). On the other hand, the lowest percent yield increased over control (12.16%) was recorded in T_2 followed by T_1 (15.21%) treated plot.

Table 6 Effect of different insecticides on yield of mustard during the management of mustard aphid in the field

Treatment	Yield of mustard		% yield increase over control
	Yield (g/plot)	Yield (kg/ha)	
T_1	210.3 bc	701.1 bc	15.21
T_2	203.0 c	676.7 c	12.16
T_3	212.0 bc	706.7 bc	15.89
T_4	233.7 a	778.9 a	23.68
T_5	218.3 b	727.8 b	18.32
T_6	178.3 d	594.4 d	-
LSD $_{(0.05)}$	11.14	40.55	-
CV (%)	2.96	2.96	-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that, among five treatments T_4 comprised of spraying of Aktara 25 WG @ 0.5 g/l water applied at 7 days interval was the most effective insecticide in increasing the highest percent yield (23.68%) over control followed by Ripcord, Marshal, Malathion, whereas Sevin 85 WP showed the least performance in increasing the yield (12.16%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of increasing the yield of mustard in t ha^{-1} was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_3 (Marshal 20EC) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_6 (Untreated control). About similar research was also carried out by Sultana (2009) on the management on mustard aphid (*Lipaphis erysimi)* using Neem Kernel extract with two chemical insecticides Aktara 25 WG and Diazinon 60 EC. Among the treatments, the highest yield (1568 kg ha^{-1}) was also found in Aktara treated plot which was statistically similar to Diazinon treated plot (1485 kg ha^{-1}) and gave the highest BCR (4.20) followed by Diazinon and Neem Kernel extract. Khan (1999) also stated that significantly high grain yield of 1.20 kg /plot (15 m^2 size) was obtained in Ripcord 10 EC treated plot compared to grain yield of 0.75 kg/plot obtained from untreated plot.

4.4. Effect of insecticides on the incidence of predatory insects of mustard aphid

Significant variations of the effect of different insecticides on the incidence of adults and larvae of predatory lady bird beetle population observed by direct visual count and settings of pitfall trap. Ant and other soil dwelling insects were also observed by pitfall trap in the mustard field. The results of the study have also been described and discussed below:

4.4.1 Effect of insecticides on the incidence of predatory ladybird beetle

Statistically significant variation was observed among the results of different management practices in terms of ladybird adults and larvae at different DAS of mustard seed during the management of mustard aphid (Table 7).

4.4.1.1a. Incidence of larvae of ladybird beetle by visual count

In case of 52 DAS, the highest number of ladybird beetle larvae (3.33 larvae/plot) was recorded in untreated control plot, which was statistically higher from all other treatment followed by T_3 (3.00 larvae/plot) comprised of spraying of Marshal 20 EC @ 3 ml/l of water at 7 days interval and T_1 (2.67 larvae/plot) comprised of spraying of

Malathion 57 EC @ 3ml/l of water at 7 days interval (Table 7). On the other hand, the lowest number of larvae (1.67 larvae/plot) was recorded in T_4 comprising Aktara 25 WG spraying @ 0.5 gml/l of water at 7 days interval which was followed by T_5 (2.00 larvae/plot) comprised of spraying Ripcord 10 EC @ 3 ml/l of water at 7 days interval and T_2 (2.33 larvae/plot) comprised of spraying Sevin 85 WP @ 4 gml/l of water at 7 days interval. In case 59 DAS, the highest number of larvae (2.33 larvae/plot) was recorded in control plot which was followed by T_2 (2.00 larvae/plot) and T_1 (1.67 larvae/plot). On the other hand, the lowest number of ladybird beetle larvae (0.67 larvae/plot) was recorded in T_4 followed by T_5 (1.33 larvae/plot) and T_3 (1.33 larvae/plot). In case of 66 DAS, more or less similar trends were observed among different management practice in terms of number ladybird larvae during the management of mustard aphid in the field (Table 7).

Considering the mean of incidence of ladybird larvae, the highest number (2.00 larvae/plot) was recorded in control plot followed by T_1 (1.89 larvae/plot) and T_3 (1.78 larvae/plot) presented in Table 7. On the other hand, the lowest number of lady bird larvae (1.00 larvae/plot) was recorded in T_4 followed by T_5 (1.22 larvae/plot) and T_2 (1.66 larvae/plot).

In case of percent reduction of ladybird beetle larvae over control, the highest reduction (100%) was recorded in T_4 followed by T_5 (63.53%) and T_2 (20.26%). On the other hand, the lowest percent reduction of lady bird larvae (5.82%) was recorded in T_1 followed by T_3 (12.36%).

Table 7 Effect of different insecticides on the incidence of ladybird beetle larvae by visual count in the mustard field

Treatment	Ladybird beetle larvae (No./plot)				% reduction of ladybird larvae over control
	52 DAS	59 DAS	66 DAS	Mean	
T_1	2.67 abc	1.67 ab	1.33 ab	1.89 a	5.82
T_2	2.33 bcd	2.00 ab	1.00 ab	1.66 ab	20.26
T_3	3.00 ab	1.33 bc	1.00 ab	1.78 ab	12.36
T_4	1.67 d	0.67 c	0.67 b	1.00 c	100.00
T_5	2.00cd	1.33 bc	0.33 b	1.23 bc	63.53
T_6	3.33 a	2.33 a	2.00 a	2.00 a	-
LSD $_{(0.05)}$	0.92	0.99	1.09	0.60	-
CV (%)	20.58	35.40	56.35	14.06	-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that, among five treatments T_4 comprised of spraying of Aktara 25 WG @ 0.5 g/l of water performed as the most hazardous insecticide in reducing the highest percent of ladybird beetle larvae (100.00%) over control followed by Ripcord, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ladybird beetle larvae (5.82%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the population of ladybird beetle larvae was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_5 (Ripcord 10EC) > T_4 (Aktara 25 WG). Youn *et al.* (2003) reported that some of the ladybird beetles are susceptible to chemical insecticides chlorpyrifos and pirmicarb at the recommended rates. Generally, the 1st and 2nd instars of ladybird beetles were very sensitive to thiamethoxam (Aktara) and Abamectin but these chemicals are very effective against aphids.

4.4.1.1b. Incidence of adult ladybird beetles by visual count

Statistically significant variation was observed among the results of different management practices in terms of ladybird beetle by visual count at different DAS of mustard seed during the management of mustard aphid (Table 8). In case of 52 DAS, the highest number of adult ladybird beetle (2.67 beetle/plot) was recorded in untreated control plot (T_6) followed by T_3 (2.00 beetle/plot) and T_1 (3.00 beetle/plot) (Table 8). On the other hand, the lowest number of adult ladybird beetle (1.00 beetle/plot) was recorded in T_5 comprised of spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval and followed by T_4 (1.33 beetle/plot) comprised of spraying of Aktara 25 WG @ 0.5g/l of water at 7 days interval and T_2 (1.67 beetle/plot) comprised of spraying Sevin 85 WP @ 4 g/l of water at 7 days interval. In case 59 DAS, the highest number of adult ladybird beetle (2.33 beetle/plot) was recorded in control plot which was statistically different from all other treatment followed by T_2 (1.67 beetle/plot) and T_1 (1.67 beetle/plot). On the other hand, the lowest number of adult ladybird beetle (0.67 beetle/plot) was recorded in T_4. In case of 66 DAS, more or less similar trends were observed among different management practice in terms of number ladybird beetle during the management of mustard aphid in the field (Table 8).

Considering the mean of ladybird beetle, the highest number of adult ladybird beetle (1.67 beetle/plot) was recorded in control plot followed by T_1 (1.55 beetle/plot) and T_3 (1.44 beetle/plot) presented in Table 8. On the other hand, the lowest number of lady bird beetle (0.67 beetle/plot) was recorded in T_5 followed by T_4 (0.78 beetle/plot).

In case of percentage decrease over control, the highest reduction (149.25%) was recorded in T_5 followed by T_4 (114.10%) and T_2 (50.45%). On the other hand, the lowest reduction (7.25%) was recorded in T_1 followed by T_3 (15.73%).

Table 8 Effect of different insecticides on the incidence of adult ladybird beetle by visual count in the mustard field

Treatment	Adult ladybird beetle (No./plot)				% reduction of adult ladybird beetle over control
	52 DAS	59 DAS	66 DAS	Mean	
T_1	2.00 abc	1.67 ab	1.00 ab	1.55 a	7.25
T_2	1.67 bcd	1.67 ab	1.00 ab	1.11 b	50.45
T_3	2.00 abc	1.00 b	0.67 abc	1.44 a	15.72
T_4	1.33 cd	0.67 b	0.00 c	0.78 c	114.10
T_5	1.00 d	1.67 ab	0.33 bc	0.67 c	149.25
T_6	2.67 a	2.33 a	1.33 a	1.67 a	-
$LSD_{(0.05)}$	0.79	1.06	0.70	0.03	-
CV (%)	23.98	41.31	52.29		-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that, the T_5 comprising Ripcord 10EC 3 ml/l of water performed as the most hazardous insecticide in reducing the highest population of adult ladybird beetle (149.25%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of adult ladybird beetle (7.25%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the adult population of ladybird beetle was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC). Tewary (1983) reported that Cypermethrin, Malathion and Carbaryl were less toxic to aphid but gave high mortality of the ladybird beetle.

4.4.2a. Incidence of larvae of ladybird beetle by pitfall trap

Statistically significant variation was observed among different management practices in terms of ladybird larvae counted by using pitfall trap at different DAS of mustard seed during the management of mustard aphid (Table 9). In case of 52 DAS, the highest number of ladybird beetle larvae (5.33 larvae/trap) was recorded in untreated control plot (T_6) followed by T_1 (5.00 larvae/trap) comprised of spraying of Malation 57 EC @ 3 ml/l of water applied at 7 days interval and T_2 (5.00 larvae/trap) comprised of spraying of Marshal 20 EC @ 3ml/l of water sprayed at 7 days interval and T_3 (5.00 larvae/trap) comprised of spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval (Table 9). On the other hand, the lowest number of larvae (3.67 larvae/trap) was recorded in T_4 comprised of spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval and was followed by T_5 (4.00 larvae/trap) comprised of spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval. In case 59 DAS, the highest number of ladybird beetle larvae (4.00 larvae/trap) in pitfall trap was recorded in T_6 which was statistically similar with T_1 (4.00 larvae/trap) and followed by T_2 (3.67 larvae/trap) showed in (Table9). On the other hand, the lowest number of ladybird beetle larvae (2.67 larvae/trap) was recorded in T_5 followed by T_4 (3.33 larvae/trap) and T_3 (3.33 larvae/trap). In case of 66 DAS, more or less similar trends were observed among different management practice in terms of number ladybird larvae during the management of mustard aphid in the field (Table 9).

Considering the mean number of ladybird beetle larvae, the highest number of larvae (4.22 larvae/trap) was recorded in control plot followed by T_1 (2.67 larvae/trap) and T_3 (2.33 larvae/trap) presented in Table 9. On the other hand, the lowest number of lady bird larvae (1.00 larvae/trap) was recorded in T_5 followed by T_4 (1.33 larvae/trap). Similarly, in case of percent decrease of ladybird beetle larvae over control, the highest percent of lady bird larvae reduction (65.06%) was recorded in T_5 followed by T_4 (51.98%) and T_3 (18.76%). On the other hand, the lowest percentage of lady bird larvae reduction (8.48%) was recorded in T_1 followed by T_3 (18.65%).

Table 9 Effect of different insecticides on the incidence of ladybird beetle larvae counted by pitfall trap during the management of mustard aphid in the field

Treatment	Ladybird beetle larvae (No./trap)				% reduction of lady bird larvae over control
	52 DAS	59 DAS	66 DAS	52 DAS	
T_1	5.00 ab	4.00 a	2.67 ab	3.89 ab	8.48
T_2	5.00 ab	3.67 ab	2.00 bcd	3.56 ba	18.65
T_3	5.00 ab	3.33 ab	2.33 abc	3.55 ab	18.76
T_4	3.67 c	3.33 ab	1.33 cd	2.78 c	51.98
T_5	4.00 bc	2.67 b	1.00 d	2.56 c	65.06
T_6	5.33 a	4.00 a	3.33 a	4.22 a	-
LSD $_{(0.05)}$	1.18	1.23	1.30	0.8	-
CV (%)	14.00	19.75	34.28		-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that T_5 comprised of spraying of Ripcord 10EC 3 ml/l of water sprayed at 7 days interval performed as the most hazardous insecticide in reducing the highest percent of ladybird beetle larvae (65.06%) over control followed by Aktara, Marshal, Sevin, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ladybird beetle larvae (8.48%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the incidence of ladybird beetle larvae counted by pitfall trap was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_3 (Marshal 20EC) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC). Youn *et al.* (2003) reported that the 1st and 2nd instars of ladybird beetles were very sensitive to thiamethoxam (Aktara) but these chemicals are very effective against aphids.

4.4.2b. Incidence of adult ladybird beetle counted by pitfall trap

Statistically significant variation was observed among the results of pitfall trap in terms of adult ladybird beetle collected at different DAS of mustard seed during the management of mustard aphid (10). In case of 52 DAS, the highest number of adult ladybird beetle (4.33 beetle/trap) was recorded in untreated control plot (T_6) followed by T_1 (3.67 beetle/trap) comprised of spraying of Malation 57 EC @ 3 ml/l of water at 7 days interval and T_3 (3.67 beetle/trap) comprised of spraying of Marshal @ 3ml/l of water at 7 days interval (Table 10). On the other hand, the lowest number of beetle (2.67 beetle/trap) was recorded in T_5 comprised of spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval and followed by T_4 (3.00 beetle/trap) comprised of spraying of Aktara 25 WG @ 0.5g/l of water at 7 days interval and T_2 (3.33 beetle/trap). In case 59 DAS, the highest number of adult ladybird beetle (2.67 beetle/trap) was recorded in control plot which was statistically similar with T_1 (2.67 beetle/trap), T_2 (2.67 beetle/trap) and T_3 (2.67 beetle/trap). On the other hand, the lowest number of lady bird beetle (1.33 beetle/trap) was recorded in T_4 followed by T_5 (1.67 beetle/trap). In case of 66 DAS, the highest number of adult beetle (2.33 beetle/trap) was recorded in control plot followed by T_1 (1.67 beetle/trap) and T_6 (1.67 beetle/trap). On the other hand, the lowest number of lady bird beetle (0.67 beetle/trap) was recorded in T_5 followed by T_4 (1.00 beetle/trap) presented in Table 10.

Considering the mean incidence of adult ladybird beetle, the highest number (3.11 beetle/trap) was recorded in control plot followed by T_1 (2.78 beetle/trap) and T_3 (2.66 beetle/trap) presented in Table 10. On the other hand, the lowest number of adult ladybird beetle (1.67 beetle/trap) was recorded in T_5 followed by T_4 (1.78 beetle/trap) and T_2 (2.55 beetle/trap). Similarly, in case of percent decrease of adult ladybird beetle population over control, the highest percent of adult ladybird beetle reduction

(86.56%) was recorded in T_5 followed by T_4 (75.01%) and T_2 (21.82%). On the other hand, the lowest percent reduction of adult ladybird beetle (11.87%) was recorded in T_1 followed by T_3 (16.61%).

Table 10 Effect of different insecticides on the incidence of ladybird beetle counted by pitfall trap during the management of mustard aphid in the field

Treatment	Adult ladybird beetle (No./trap)				% reduction of adult ladybird beetle over control
	52 DAS	59 DAS	66 DAS	Mean	
T_1	3.67 ab	2.67 a	2.00 ab	2.78 a	11.87
T_2	3.33 ab	2.67 a	1.67 abc	2.55 ab	21.82
T_3	3.67 ab	2.67 a	1.67 abc	2.67 a	16.61
T_4	3.00 ab	1.33 b	1.00 bc	1.77 bc	75.01
T_5	2.67 b	1.67 b	0.67 c	1.67 c	86.56
T_6	4.33 a	2.67 a	2.33 a	3.11 a	-
$LSD_{(0.05)}$	1.51	1.12	1.17	0.80	-
CV (%)	24.12	24.05	39.64		-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that T_5 comprised of spraying of Ripcord 10EC 3 ml/l of water performed as the most hazardous insecticide in reducing the highest percent of adult ladybird beetle (86.56%) over control followed by Aktara, Marshal, Sevin, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of adult ladybird beetle (11.87%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the incidence of ladybird beetle larvae counted by pitfall trap was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC). Tewary (1983) reported that

Cypermethrin, malathion and carbaryl were less toxic to aphid but gave high mortality of the ladybird beetle.

4.4.3 Incidence of ant counted by pitfall trap

Statistically significant variation was observed among different management practices in terms of the incidence of black ant counted by using pitfall trap at different DAS of mustard seed during the management of mustard aphid (Table 11). In case of 52 DAS, the highest number of ant (7.00 ant/trap) was recorded in untreated control plot (T_6) followed by T_2 (6.00 ant/trap) comprised of spraying of Sevin 85 wp @ 4 g/l of water at 7 days interval and T_3 (6.00 ant/trap) comprised of spraying of Marshal @ 3ml/l of water at 7 days interval. On the other hand, the lowest number of ant (4.67 ant/trap) was recorded in T_5 comprised of spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval and is was statistically similar to that of T_4 (4.67 ant/trap) comprised of spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval followed by T_1 (5.33 ant/trap). In case 59 DAS, the highest number (6.00 ant/trap) of ant in pitfall trap was recorded in control plot (T_6) which was statistically different from any other treatment. It was followed by T_1 (4.67 ant/pitfall trap) and T_3 (3.67 ant/pitfall trap). On the other hand the lowest number of ant (2.67 ant/pitfall trap) was recorded in T_5 followed by T_2 (3.33 ant/pitfall trap) and T_4 (3.67 ant/pitfall trap). In case of 66 DAS, more or less similar trends were observed among different management practice in terms of number ant during the management of mustard aphid in the field (Table 11).

Considering the mean incidence of ant, the highest number of ant (6.22 ant/pitfall trap) was recorded in control plot (T_6) followed by T_1 (4.67 ant/pitfall trap) and T_3 (4.44 ant/pitfall trap) presented in Table 11. On the other hand, the lowest number of ant (3.00 ant/pitfall trap) was recorded in T_5 followed by T_4 (3.34 ant/pitfall trap). Considering the percent reduction of ant population over control, the highest percent reduction of ant (107.43%) over control was recorded in T_5 followed by T_4 (80.74 %) and T_2 (59.97%). On the other hand, the lowest reduction (33.34%) was recorded in T_1 followed by T_3 (40.06%).

Table 11 Effect of different insecticides on the incidence of black ant counted by pitfall trap during the management of mustard aphid in the field

Treatment	Ant population (No./Pitfall trap*)				% reduction of ant population over control
	52 DAS	59 DAS	66 DAS	Mean	
T_1	6.00 ab	4.67 bc	3.33 c	4.67 b	33.34
T_2	6.00 ab	3.33 d	2.33 d	3.89 bc	59.97
T_3	5.33 ab	3.67 cd	4.33 b	4.44 b	40.06
T_4	4.67 b	3.67 cd	2.00 d	3.44 cd	80.74
T_5	4.67 b	2.67 d	1.67 d	3.00 d	107.43
T_6	7.00 a	6.00 a	5.67 a	6.22 a	-
LSD $_{(0.05)}$	2.06	1.33	1.28	0.86	-
CV (%)	20.27	17.71	19.85		-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that T_5 comprised of spraying of Ripcord 10EC 3 ml/l of water at 7 days interval performed as the most hazardous insecticide in reducing the highest percent of ant population (107.43%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ant population (33.34%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the incidence of ant population counted by pitfall trap was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC).

4.5. Incidence of other soil dwelling insects counted by pitfall trap

Statistically significant variation was observed among different management practices in terms of the incidence of other soil dwelling insects counted by pitfall trap at different DAS of mustard seed during the management of mustard aphid (Table 12). In case of 52 DAS, the highest number of soil dwelling insects (5.33 per trap) was recorded in untreated control plot (T_6) followed by T_2 (4.33 per trap) comprised of spraying Sevin 85 WP @ 4 g/l of water at 7 days interval and T_1 (4.33 per trap) comprised of spraying of Marshal 20 EC @ 3 ml/l of water at 7 days interval. On the other hand, the lowest number of soil dwelling insect (2.33 per trap) was recorded in T_5 comprised of spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval and was statistically similar with T_4 (3.33 per trap) comprised of spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval followed by T_3 (5.33 per trap) comprised of Marshal 20 EC @ 2 ml/l of water. In case 59 DAS, the highest number of soil dwelling insects (3.67 per trap) was recorded in untreated control plot ($T_{6)}$, which was statistically different from any other treatments. It was followed by T_2 (3.33 per trap) and T_1 (2.33 per trap). On the other hand, at 59 DAS the lowest number of soil dwelling insects (1.33 per trap) was recorded in T_5 followed by T_2 (1.67 per trap) and T_4 (1.67 per trap) presented in Table 12. In case of 66 DAS, more or less similar trends were observed among different management practice in terms of number other soil dwelling insects during the management of mustard aphid in the field (Table 12).

Considering the mean incidence of soil dwelling insects, the highest number of insects (5.55 per trap) was recorded in control plot followed by T_1 (4.11 per trap) and T_3 (4.00 per trap) presented in Table 12. On the other hand, the lowest number of soil dwelling insect (2.23 per trap) was recorded in T_5 followed by T_4 (3.00 per trap). Similarly, in case of percent reduction of soil dwelling insects over control, the highest reduction

(149.98%) was recorded in T_5 followed by T_4 (85.23%) and T_2 (66.73%). However, the lowest reduction (35.21%) was recorded in T_1 followed by T_2 (38.93%).

Table 12 Effect of different insecticides on the incidence of other soil dwelling insects counted by pitfall trap during the management of mustard aphid in the field

Treatment	Other soil dwelling insects (No./trap)				% reduction of other soil dwelling insects over control
	52 DAS	59 DAS	66 DAS	Mean	
T_1	4.33 ab	2.33 bc	1.33 bc	4.11 b	35.21
T_2	4.33 ab	3.33 ab	1.67 b	3.33 cd	66.73
T_3	4.00 ab	1.67 c	1.67 b	4.00 bc	38.93
T_4	3.33 bc	1.67 c	0.67 c	3.00 d	85.23
T_5	2.33 c	1.33 c	0.67 c	2.22 e	149.98
T_6	5.33 a	3.67 a	2.67 a	5.55 a	-
$LSD_{(0.05)}$	1.51	1.03	0.94	0.67	-
CV (%)	20.75	22.88	24.59		-

Means followed by same letter(s) in a column do not differ significantly at 5% by DMRT

[T_1 = Spraying of Malathion 57 EC @ 2 ml/l of water at 7 days interval, T_2 = Spraying of Sevin 85 WP @ 4 g/l of water at 7 days interval, T_3 = Spraying of Marshal 20 EC @ 2 ml/l of water at 7 days interval, T_4 = Spraying of Aktara 25 WG @ 0.5 g/l of water at 7 days interval, T_5 = Spraying of Ripcord 10 EC @ 3 ml/l of water at 7 days interval, T_6 = Untreated control]

From the above finding it was revealed that T_5 comprised of spraying of Ripcord 10EC 3 ml/l of water applied at 7 days interval performed as the most hazardous insecticide in reducing the highest percent of other soil dwelling insect population (149.98%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of other soil dwelling insect population (35.21%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the incidence of other soil dwelling insect population counted by pitfall trap was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_4

(Aktara 25 WG) > T_5 (Ripcord 10EC). About similar results were also observed by Islam (1991) and Sultana (2009).

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the Rabi season 2010-2011 to evaluate the efficacy of some promising chemical insecticides on mustard aphid infestation as well as their impact on the incidence of predatory ladybird beetle and other beneficial insects in mustard field. The treatments of the experiment were composed of five promising chemical insecticides and one untreated control viz. T_1 = Malathion 57 EC @ 2 ml/l of water, T_2 = Sevin 85 WP @ 4 g/l of water, T_3 = Marshal 20 EC @ 2 ml/l of water, T_4 = Aktara 25 WG @ 0.5 g/l of water, T_5 = Ripcord 10 EC @ 3 ml/l of water, T_6 = Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The data were recorded on incidence of aphid population by number, pod formation, pod infestation, pod deformation, 1000 seed weight and yield of mustard; as well as the incidence of larvae and adults of ladybird beetle by visual count and pitfall trap, incidence of ant and other soil dwelling insects counted by using pitfall trap.

SUMMARY

In terms of the abundance of aphid population, among five insecticides, T_5 comprising Ripcord 10 EC @ 3 ml/l of water performed as the most effective insecticide in reducing the highest percent of aphid population (163.33%) over control followed by Marshal, Aktara, Malathion and Sevin, whereas Sevin 85 WP @ 4 g/l of water showed the least performance in reducing the aphid population (33.76%). As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of reducing the aphid population was T_5 (Ripcord 10EC) > T_3 (Marshal 20EC)

> T_4 (Aktara 25 WG) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_6 (Untreated control).

In respect of pod formation by number, Aktara 25 WG @ 0.5 g/l water performed as the most effective insecticide in increasing the highest percent of pod formation by number (17.20%) over control followed by Ripcord, Malathion, Sevin, whereas Marshal 20EC showed the least performance in increasing the pod formation (6.24%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of increasing the pod formation by number was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_3 (Marshal 20EC) > T_6 (Untreated control).

In terms of pod infestation, Aktara 25 WG @ 0.5 g/l water also performed as the most effective insecticide in reducing the highest percent of pod infestation by number (160.46%) over control followed by Ripcord, Marshal, Malathion, whereas Sevin 85 WP showed the least performance in reducing the pod infestation (32.71%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of reducing the pod infestation by number was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_3 (Marshal 20EC) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_6 (Untreated control).

Similarly, in terms of pod deformation, Aktara 25 WG @ 0.5 g/l water performed as the most effective insecticide in reducing the highest percent of pod deformation by number (144.29%) over control followed by Ripcord, Malathion, Marshal, whereas Sevin 85 WP showed the least performance in reducing the pod deformation (18.03%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of reducing the pod deformation by number was T_4

(Aktara 25 WG) > T_5 (Ripcord 10EC) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_6 (Untreated control).

Considering the 1000 seed weight, among five insecticides, Aktara 25 WG @ 0.5 g/l water performed as the most effective insecticide in increasing the highest percent of seed weight (30.00%) over control followed by Ripcord, Malathion, Marshal, whereas Sevin 85 WP showed the least performance in increasing 1000 seed weight (2.23%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of increasing 1000 seed weight was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_6 (Untreated control).

Similarly, in case of yield of mustard, Aktara 25 WG @ 0.5 g/l water performed as the most effective insecticide in increasing the highest percent of yield (23.68%) over control followed by Ripcord, Marshal, Malathion, whereas Sevin 85 WP showed the least performance in increasing the yield (12.16%) over control. As a result, the order of trend of efficiency of five insecticides along with untreated control in terms of increasing the yield of mustard in ton/ha was T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC) > T_3 (Marshal 20EC) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_6 (Untreated control).

In terms of the incidence of ladybird beetle larvae by visual count, Aktara 25 WG @ 0.5 g/l of water performed as the most hazardous insecticide in reducing the highest percent of ladybird beetle larvae (100.00%) over control followed by Ripcord, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ladybird beetle larvae (5.82%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the population of ladybird beetle larvae was T_6 (Untreated control) > T_1 (Malathion

57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_5 (Ripcord 10EC) > T_4 (Aktara 25 WG).

In terms of the incidence of ladybird beetle adult by visual count, Ripcord 10EC 3ml/l of water performed as the most hazardous insecticide in reducing the highest population of adult ladybird beetle (149.25%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of adult ladybird beetle (7.25%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the adult population of ladybird beetle was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC).

Considering the incidence of ladybird beetle larvae counted by using pitfall trap, Ripcord 10EC 3 ml/l of water performed as the most hazardous insecticide in reducing the highest percent of ladybird beetle larvae (65.06%) over control followed by Aktara, Marshal, Sevin, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ladybird beetle larvae (8.48%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the incidence of ladybird beetle larvae counted by using pitfall trap was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_2 (Sevin 85WP) > T_3 (Marshal 20EC) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC).

Similarly, in terms of the incidence of adult ladybird beetle counted by pitfall trap, Ripcord 10EC 3 ml/l of water performed as the most hazardous insecticide in reducing the highest percent of adult ladybird beetle (86.56%) over control followed by Aktara, Marshal, Sevin, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of adult ladybird beetle

(11.87%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the incidence of ladybird beetle larvae counted by pitfall trap was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC).

Considering the incidence of ant population counted by pitfall trap, Ripcord 10EC 3 ml/l of water performed as the most hazardous insecticide in reducing the highest percent of ant population (107.43%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ant population (33.34%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the incidence of ant population counted by using pitfall trap was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC).

Considering the incidence of other soil dwelling insects counted by using pitfall trap, Ripcord 10EC 3 ml/l of water also performed as the most hazardous insecticide in reducing the highest percent of soil dwelling insect population (149.98%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of soil dwelling insect population (35.21%). As a result, the order of trend of less hazardous insecticides along with untreated control in terms of reducing the incidence of soil dwelling insect population counted by using pitfall trap was T_6 (Untreated control) > T_1 (Malathion 57EC) > T_3 (Marshal 20EC) > T_2 (Sevin 85WP) > T_4 (Aktara 25 WG) > T_5 (Ripcord 10EC).

CONCLUSION

Based on the above findings of the study, the following conclusions have been drawn:

In case of efficacy of insecticides on aphid infestation and yield of mustard

- Ripcord 10 EC @ 3 ml/l of water applied at 7 days interval performed as the most effective insecticide in reducing the highest percent of aphid population (163.33%) over control followed by Aktara, Marshal, Malathion and Sevin, whereas Sevin 85 WP @ 4 g/l of water showed the least performance in reducing the aphid population (33.76%).
- In terms of pod formation, Aktara 25 WG @ 0.5 g/l water sprayed at 7 days interval performed as the most effective insecticide in increasing the highest percent of pod formation (17.20%) over control followed by Ripcord, Malathion, Sevin, whereas Marshal 20EC showed the least performance in increasing the pod formation (6.24%) over control.
- Aktara 25 WG also performed as the most effective insecticide in reducing the highest percent of pod infestation (160.46%) and pod deformation (144.29%) over control followed by Ripcord, Marshal, Malathion, whereas Sevin 85 WP showed the least performance in reducing the pod infestation (32.71%) and pod deformation (18.03%) over control.
- Aktara 25 WG performed as the most effective insecticide in increasing the highest percent of seed weight (30.00%) and yield (23.68%) of mustard over control followed by Ripcord, Malathion, Marshal, whereas Sevin 85 WP showed the least performance in increasing 1000 seed weight (2.23%) and yield (12.16%) over control.

Impact of insecticides on the population of ladybird beetle and other insects

- In case of visual counts, Aktara 25 WG 0.5 g/l water sprayed at 7 days interval performed as the most hazardous insecticide in terms of reducing the highest percent of ladybird beetle larvae (100.00%) over control followed by Ripcord, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ladybird beetle larvae (5.82%).
- Conversely, Ripcord 10EC 3 ml/l of water applied at 7 days interval performed as the most hazardous insecticide in terms of reducing the highest percent of adult ladybird beetle (149.25%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of adult ladybird beetle (7.25%).
- In case of pitfall trap, Ripcord 10EC 3 ml/l of water applied at 7 days interval performed as the most hazardous insecticide in reducing the highest percent of ladybird beetle larvae (65.06%) and adult (86.56%) over control followed by Aktara, Marshal, Sevin, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ladybird beetle larvae (8.48%) and adult (11.87%).
- In case of ant population and other soil insects, Ripcord 10EC 3 ml/l of water sprayed at 7 days interval performed as the most hazardous insecticide in reducing the highest percent of ant population (107.43%) and other soil insects (149.98%) over control followed by Aktara, Sevin, Marshal, whereas Malathion 57 EC performed as the least hazardous insecticide and reduced the lowest percent of ant population (33.34%) and other soil insects (35.21%).

RECOMMENDATIONS

Considering the findings of the study following recommendations may be drawn:

Aktara 25 WG and Ripord 10 EC should be recommended as effective insecticides for the management of mustard aphid as compared with Sevin 85 WP, Marshal 20 EC and Malathion 57 EC;

1. Conversely, Malathion 57 EC should be recommended as least hazardous insecticides for predatory ladybird beetle and other beneficial insects in the field condition.
2. Further intensive studies based on different doses of Aktara 25 WG, Ripcord 10 EC and Malathion 57 EC should be done.
3. More chemicals insecticides should be included in further research for controlling mustard aphid in different agro-ecological zones of Bangladesh.

CHAPTER VI

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