

**EFFECT OF INTERCROPPING WITH MUSTARD ON INCIDENCE
OF APHID (*LIPAPHIS ERYSIMI*)**

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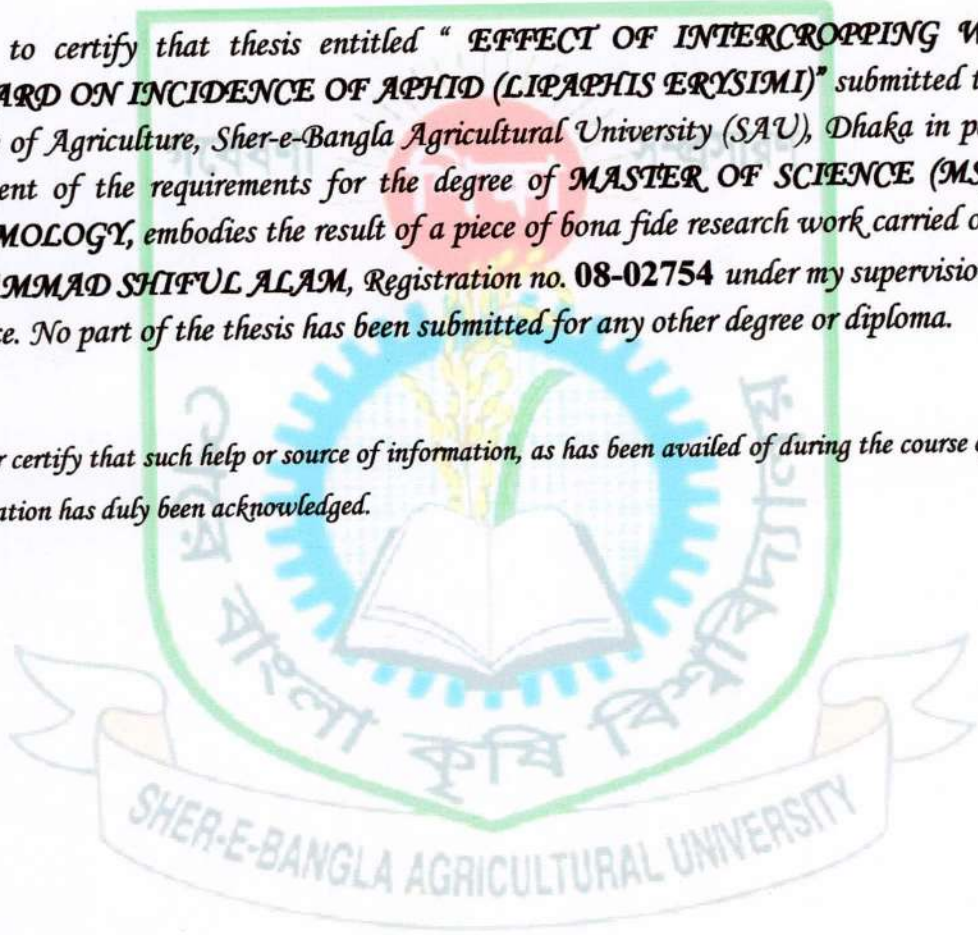


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CERTIFICATE


This is to certify that thesis entitled "**EFFECT OF INTERCROPPING WITH MUSTARD ON INCIDENCE OF APHID (LIPAPHIS ERYSIMI)**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MOHAMMAD SHIFUL ALAM**, Registration no. **08-02754** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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



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**DEDICATED TO
MY
BELOVED PARENTS**

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ABBREVIATIONS AND ACRONYMS

AEZ	:	Agro-Ecological Zone
<i>et al.</i>	:	And associates
BBS	:	Bangladesh Bureau of Statistics
CV	:	Coefficient of variation
DAS	:	Days After Sowing
DMRT	:	Duncan's Multiple Range Test
df	:	Degrees of freedom
etc.	:	Et cetera
FAO	:	Food and Agriculture Organization
g	:	Gram
ha	:	Hectare
J.	:	Journal
Kg	:	Kilogram
LSD	:	Least Significant Difference
MS	:	Mean sum of square
MP	:	Muriate of Potash
no.	:	Number
%	:	Percent
SAU	:	Sher-e-Bangla Agricultural University
m ²	:	Square meter
t	:	Ton
TSP	:	Triple Super Phosphate

**EFFECT OF INTERCROPPING WITH MUSTARD ON INCIDENCE OF
APHID (*LIPAPHIS ERYSIMI*)**

By

MOHAMMAD SHIFUL ALAM

ABSTRACT

The experiment was conducted in the research field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during the period from November, 2013 to February, 2014 to evaluate the effect of intercropping on the incidence of mustard aphid. The experiment consists of six treatments such as Mustard with coriander, Mustard with fenugreek, Mustard with radhuni, Mustard with black cumin, Mustard with wheat and control (Mustard sole). It was laid out in Randomized Complete Block Design (RCBD) with three replications. Sole cropping of mustard was grown to compare the effectiveness of other intercropping treatments. The lowest number of infested plant per plot (17.82), flower infestation per plant (17.72%), total branch per infested plant (4.39), siliqua infestation per plant (65.13%) were recorded in mustard with coriander intercropping treatment. On the contrary, the highest number 33.96, 32.78%, 5.46, 98.08% respectively were recorded in control treatment. The maximum number of total siliqua per infested branch (25.73), total seed per infested siliqua (23.20), total seed weight per infested plant (8.86g) and total yield (0.49 t/ha) were recorded in mustard with coriander intercropping treatment and the lowest result 17.83, 15.97, 4.67g, 0.19 t/ha respectively were recorded in control treatment. Among the intercropping combinations, mustard with coriander was the most effective treatment for the management of mustard aphid as well as producing the highest yield.

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SAU, Dhaka

The Author

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Chapter I

Introduction

CHAPTER I

INTRODUCTION

Mustard belongs to the genus *Brassica* of the family Cruciferae symbolized by rapeseed and is one of the leading oilseed crops in Bangladesh as well as in the World. It plays a vital role in human nutrition. It is used as a condiment, salad, green manure and fodder crop, and as a leaf and stem vegetable in the various mustard growing countries of the World (FAO, 2004). Mustard oil cake has been using as fertilizer in the South Asian region for centuries. In combination with cowdung manure and ashes, the oil cakes sustained the fertility levels of marginal farms. Oil cakes render indirect help in promoting the microflora and microfauna of soils providing readily available amino acids and free sugars. It is clear that oil cakes are rich sources of nitrogen, phosphorus and potassium micronutrients (Dhaliwal and Dilawary, 1993). Mustard oil cake also used as nutritive food of the cattles.

In Bangladesh more than 218.47 thousand metric tons of rape and mustard were produced from a total of 287.55 thousand hectars of land in the year 2007-2008 (BBS, 2009). Mustard occupies the top of the list in respect of area and production as compared to other oilseed crops grown in Bangladesh (Abraham, 1994).

Domestic production of edible oil almost entirely comes from rapeseed and mustard occupying only about 2% area of total cropped area in Bangladesh (BBS, 2002). The annual oil seed production of 0.41 million tons of which the share of rapeseed-mustard was 0.21 million tons, which comes about 52% of the total edible oil seed production (BBS, 2009).

Bangladesh is running with acute shortage of edible oil and it is about 71% of the total requirement of the country. Annually producing about 0.16 million tons of edible oil as against the requirement of 0.5 million tons. To meet up the demand, the country has to

import oil and oilseeds to the tune of about 160 million US \$ every year (Wahhab *et al.*, 2002).

However the yield of Mustard is hampered every year by different pathogens and insects like aphid, sawfly and mustard leaf eating caterpillar. Out of which mustard aphid, *Lipaphis erysimi* (Kalt.) (Homoptera: Aphididae) is the most destructive one (Das, 2002). Mustard aphid is the most common serious and destructive pest of mustard in South Asia (Zaman, 1990 and Bakhetia, 1983). The reproduction rate varies from 5-9 young in a single day by a single female and the total number of young produced by the female varies from 76-188 (Nair, 1986). Both the nymph and adult aphid suck sap from leaves, stems, inflorescences and pods, as a result the plant show stunted growth, flowers wither and pod formation is hindered (Atwal and Dhaliwal, 1997; Begum, 1995; Butane and Jotwani, 1984).

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

through agronomic manipulation that is intercropping may be considered as one of the possible alternate options. Intercropping of diverse growth habit crops have been found as a very useful technique in controlling a large number of crop pests (Singh and Rathi, 2003).

✓ Intercropping is a simple and inexpensive strategy and has been recognized as a potential technology to increase crop production due to its substantial yield advantage than sole cropping (Atwal *et al.*, 2006). The purpose of intercropping is to generate beneficial biological interactions between the crops. Intercropping can increase yields, more efficiently use available resources, reduce weed, insect and disease pressures and provide greater biological and economic stability (Vandermeer, 1989). Intercropping has been an essential production method in tropical regions for hundreds of years (Vandermeer, 1989) and to a lesser extent in temperate regions (Li *et al.*, 2001). Intercropping was once common in temperate regions, but has been largely replaced in the last 150 years by monocultures (Francis, 1986).

Intercropping offers an excellent opportunity of ecological management by bringing about changes in crop geometry and cropping system, which may have economically relevant impact on pest damage (Wilken, 1972). There is a general agreement that species diversity in multiple cropping reduces the most insect pest problems, increase cropping intensity and can successfully out compete to weeds. In intercropping, two or more plant species in the field may disrupt the host plant finding behavior of insects. Intercropping can affect the microclimate of the agro-ecosystem, which ultimately produces an unfavorable environment for the pest (Singh and Singh, 1978). The olfactory stimulus offered by the main crop could be camouflaged by various intercrops (Aiyer, 1949).

By intercropping it is advantageously possible that one plant species may serve as a trap for insects, reducing infestation of the other or that it may serve as a breeding place for

predators. In general the greater number of hosts in the intercropping generally also means a greater diversity of pests and diseases. Other advantages of intercropping are more efficient use of field and avoiding the risk of monocrop failure.

Several field trials on mustard have been conducted till to date using different intercrops such as banana (Rahman *et al.*, 2006), barley (Gangasaran and Giri, 1985), bean (Morse *et al.*, 1997); cabbage (Bender *et al.*, 1999), chickpea (Singh and Rathi, 2003), chilli (Mamun *et al.*, 2002), coriander (Sing and Kothari, 1997), gram (Tahir *et al.*, 2003), groundnut (Dhyani and Tripathi, 1999), linseed (Tahir *et al.*, 2003), lentil (Tahir *et al.*, 2003), oat (Morse *et al.*, 1997), Pea (Banik *et al.*, 2000), wheat (Tahir *et al.*, 2003) etc. and found lower aphid infestation on different intercropped plant than sole crops (Ma *et al.*, 2006; Nampala *et al.*, 2002). In fact, very little works have been done on intercropping of mustard with other semi season crops in Bangladesh (Mamun *et al.*, 2002; Samsuzzaman *et al.*, 1995). However, no information is available on Wheat, Fenugreek, Black cumin, coriander and radhuni intercropped with mustard. With the above prospective, intercropping has been thought to be an environment friendly option for the management of insect pests in mustard. Conceiving all thoughts and ideas, the present study has been undertaken with the following objectives:

- ✓ To study on the aphid infestation intensity on mustard due to intercropping with different species of crops.
- ✓ To find out the effect of intercropping on the management of aphid as well as the yield of mustard.



Chapter II

Review of literature

CHAPTER II

REVIEW OF LITERATURE

A number of studies on intercropping or mixed cropping and their relationship with pest management as an alternative way of using pesticides have been done and reported in Bangladesh and elsewhere in the world. However, studies in this area appeared very limited in Bangladesh. For a better understanding, clear conception and to know the research status on impact of intercropping on insect pest management, the relevant available literature have been reviewed and presented below.

Effect of intercropping on yield

Intercropping (i.e., growing more than one crop simultaneously in the same area) is one way of increasing vegetational diversity. According to Van Emden (1965) intercropping or polyculture are ecologically complex because interspecific and intraspecific plant competition occurs simultaneously with herbivores, insect predators, and insect parasitoids. Southwood (1975) stated that elimination of alternate habitats might lead to decrease predator and parasitoid populations and increased insect pest populations.

Intercropping system can be practiced to get more agronomic advantages. Simmonds *et al.* (1992) reported that *Alium* spp. are very effective antifeedant and Kirtikar and Basu (1975) reported that *Alium* spp. have strong pungent repelling action. Singh and Kothari (1997) compared aphid infestation on monocrop mustard ('Rohini') with intercrop treatments of *Artemisia* (*Artemisia annua* L.), coriander (*Coriandrum sativum* L.), chamomile (*Matricaria chamomilla* L.), fennel (*Foeniculum vulgare*) and dill (*Anethumsowa* Kurz) and found that fennel intercropped resulted in significantly lower aphid population.

Yin-Xin and Thier (2010) conducted an experiment to study the effect of tomato intercropped with five species: cucumber, maize, vegetable soybean, okra, sweet potato

(with no intercropping serving as control) on tomato yellow leaf curl virus (TYLCV) and whitefly (*Bemisia tabaci*) incidence was studied from November, 2009 to March, 2010 at ARC-AVRDC, Kasetsart University, Kamphaeng Sean, Nakhon Fathom, Thailand. TYLCV incidence and whitefly populations were recorded. TYLCV incidence on tomato increased rapidly after 58 days after transplanting. Tomato intercropped with vegetable soybean, maize, sweet potato and cucumber partly reduced the infection of TYLCV. Whitefly adults hold the highest population during January 2010 in the field. The population of whitefly larvae increased sharply from 10 January to 10 February 2010. Whitefly larvae population density in the different crops used was highly significant or significant on 37, 47, 58 and 78 DAT. Among intercrops cucumber and vegetable soybean were the preferred hosts of whiteflies.

Willey (1985) studied more above on intercropping and describe its advantages.

Aiyer (1949) formulated a three part hypothesis (1) host plants are more widely spread in intercrops, meaning they are harder to find by the pest, (2) the species serves as a trap crop to detour the pest from finding the other crop, and (3) one species may serve as a repellent to the pest.

- ✓ Risch *et al.* (1983) reported that population density of herbivorous insects are frequently lower in polyculture habitats. Two hypotheses have been proposed to explain this phenomenon, (1) the associational resistance or resource concentration hypotheses (Roots, 1973) which proposes that the specialist herbivores are generally less abundant in vegetationally diverse habitat because their food sources are less concentrated and natural enemies are more abundant and (2) the natural enemies hypothesis (Russell, 1989) which states that a diversity of plant species may provide important resources for natural enemies such as alternate prey, nectar and pollen or breeding sites.

Southwood and Way (1970) cited that the type and abundance of biodiversity in agriculture would differ across agro ecosystems, differ in age, structure and management. In fact there is a great variability in basic ecological and agronomic patterns among the various dominant agro ecosystems. In general, the degree of biodiversity in the agro ecosystems depend on four main characteristics of the agro ecosystem: 1) the diversity of vegetation within and around the agro ecosystem, (2) the performance of the various crops within the agro ecosystem, (3) the intensity of management and (4) the extent of the isolation of the agro ecosystem from natural vegetation.

✓ According to Baliddawa (1985) a specialist insect is less likely to find its hosts in diverse plant communities because of the presence of confusing or masking chemical stimuli, physical barriers to movement, and other adverse environmental factors. Consequently, insect survival may be lower.

Altieri (1994) stated that a key strategy in sustainable agriculture is to restore functional bio-diversity of the agricultural landscape. Most studies of the effects of biodiversity enhancement on insect populations have been conducted at the field level, rarely considering larger scales such as the landscape level. It is well known that spatial patterns of landscapes influence the biology of arthropods both directly and indirectly. One of the principal distinguishing characteristics of modern agricultural landscape is the large size and homogeneity of crop monocultures, which fragment the natural landscape. This can directly affect abundance and diversity of natural enemies as the larger the area under monoculture the lower the viability of given population. Altieri (1994) opined that the diversity can be enhanced in time through crop rotations and sequences and in space in the form of cover crops, intercropping, agro forestry, crop/livestock mixtures etc. Correct biodiversification results in pest regulation through restoration of natural control of insect pests, diseases and nematodes and also produces optimal nutrient cycling and soil conservation by activating

soil biota. All factors leading to sustainable yield, energy conservation and less dependence on external inputs.

Saxena (1972) stated that a proper combination of crops is important for the success of intercropping systems, when two crops are to be grown together. It is imperative that the peak period of growth of the two crop species should not coincide. Crops of varying maturity during need to be chosen so that quick maturing crops complete its life cycle before the grand period of growth of the other crop starts. However, yields of both the crops are reduced when grown as mixed or intercropped, compared with the crops when grown alone but in most cases combined yield per unit area from intercropping are higher.

Insect pests in Mustard intercropping

Mustard is the principal edible oilseed crop in Bangladesh. It is infested by a number of pests, out of which mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Homoptera: Aphididae) is the most destructive one (Das, 2002). Several field trials on mustard have been conducted till to date using different intercrops such as banana (Rahman *et al.*, 2006), barley (Gangasaran and Giri,1985), bean (Morse *et al.*, 1997), cabbage (Bender *et al.*, 1999),chickpea (Singh and Rathi, 2003;Samsuzzaman *et al.*, 1995;Gangasaran and Giri, 1985), chilli (Mamun *et al.*, 2002), coriander (Sing and Kothari, 1997), gram (Tahir *et al.*, 2003; Banik *et al.*, 2000; Bohra *et al.*, 1999;Jana *et al.*, 1995), groundnut (Dhyani and Tripathi, 1999), linseed (Tahir *et al.*, 2003),lentil (Tahir *et al.*, 2003; Banik *et al.*, 2000;Jana *et al.*,1995;Gangasaran and Giri, 1985),pea with tansy phacelia (Wnuk A., 1998),oat (Morse *et al.*,1997), Pea (Banik *et al.*, 2000), wheat (Tahir *et al.*, 2003; Zahid *et al.*, 2002) etc and found lower aphid infestation on different intercropped plant than sole crops (Ma *et al.*, 2006; Nampala *et al.*, 2002.).

✓ Intercropping of various aromatic crops (Singh and Kothari, 1997), Coriander (Tiwari *et al.*,2005), Wheat (Lasker *et al.*,2004) and Fenugreek (Mishra *et al.*, 2001) with different

Varieties of Mustard crop have been reported to reduce the population of different target pests. Hussain and Samad (1993) reported that intercropping chill with Brinjal reduces the population of *Aphis gossypii* in brinjal.

Mamun *et al.* (2002) intercropped mustard with chilli at different seedling ratios and got higher yield and profiting seedling ratio as: 26% mustard+100% chilli.

Samsuzzaman *et al.* (1995) evaluated the performance of mustard and chickpea (*Cicer arietinum*) intercropping at different levels and got best results considering yield and economic returns from mustard 75%+chickpea 25% among other combinations.

Tahir *et al.* (2003) concluded after their experiment that canola was the dominant crop in each intercropping system and wheat was more competitive followed by linseed than gram and lentils.

Bohra *et al.* (1999) studied the intercropping system of gram and mustard in different ratios and found all the intercropping treatments recorded yield advantage over sole cropping of mustard and gram.

Letourneau (1986) examined the effect of crop mixtures on squash herbivore density in the tropical low lands of Mexico. He found that *Diaphania hyalinata* (L.) the most abundant insect in the system, generally had lower population density in intercropping (maize +cowpea + squash) than in monoculture (squash alone) system.

Begum *et al.* (1995) researched over the oilseed production and pest management in Bangladesh.

Uddin *et al.* (2002) observed that polyculture generally had a greater diversity index and higher equitability of arthropod/insect community. Richness of taxonomic categories was lower in Wheat +chickpea, wheat + potato, chickpea +potato and wheat +chickpea +potato.

✓ Tiwari *et al.* (2005) observed the effect of intercropping of mustard with potato, coriander (*Coriandrum sativum*), chickpea, wheat, linseed and fenugreek on the incidence of the major insect pests, i.e. mustard aphid (*Lipaphis erysimi*), flea beetle (*Phyllotreta cruciferae*) and saw fly (*Athalia proxima*) and on the yield of mustard as sole crop and intercrops. They found that the lowest aphid population was recorded in mustard grown with coriander and the maximum population was observed on mustard as sole crop. Flea beetle incidence was minimum on mustard intercropped with linseed and maximum when sown with potato. While saw fly population was minimum on mustard sown with potato and maximum on mustard as sole crop and the yield of mustard + linseed was maximum, while a minimum return was recorded for mustard + wheat.

Mishra *et al.* (2001) examined the effects of intercrop (wheat, barley, gram, and fenugreek) on the yield of Indian mustard and the incidence of *L. erysimi*. He found that only Indian mustard + chickpea had lower mean pest incidence (24.61) than the sole Indian mustard (25.50).

Prasad *et al.* (2004) examined the insect pest incidence in linseed (cv. Neelum) intercropped with safflower (cv. A-300), Indian mustard (cv. Varuna) or gram (cv. Pant G-114) at 4:2 or 5:1 linseed-intercrop ratios and the height of linseed plants was reduced by intercropping, especially when safflower was used as the intercrop. The incidence of *Dasineura lini* in 1997-98 (26.0%) and 1998-99 (28.25%) was highest in linseed sole crop, but was significantly reduced under intercropping. The lowest incidence of *D. lini* was observed in linseed intercropped with Indian mustard at 4:2 (19.36% in 1997-98 and 21.67% in 1998-99) and 5:1 (19.99 and 22.50%), and with safflower at 4:2 (19.45 and 21.69%) and 5:1 (20.43 and 23.70%). A higher population of *Helicoverpa armigera* was recorded for linseed intercropped with gram. The lowest incidence of *H. armigera* (0.27 larva/MRL) was recorded in linseed intercropped with Indian mustard at both combinations. The highest

linseed equivalent yields in 1997-98 (1071 kg/ha) and 1998-99 (852.46 kg/ha) were obtained with linseed intercropped with Indian mustard and gram at 4:2, respectively.

Lasker *et al.* (2004) reported that early sown crop attracted lower number of aphids yet the grain yield was maximum in crop sown during the first week of December. Intercropping of mustard with various other winter season crops (wheat, barley, radish, fenugreek, spinach, coriander, pea and fennel) sown at 2:1 ratio, resulted in lower incidence of the aphid except in mustard-radish combination in which the incidence was with sole crop of mustard; the minimum incidence was found in mustard-wheat, which was with mustard-barley combination. They also reported that economic analysis of the yield data showed that although seed yield was significantly higher in sole crop of mustard yet the sale proceeds of the intercrops gave additional monetary returns which accounted for 2.39-3.62 times higher return than that from sole crop of mustard, being highest in mustard-spinach intercrop.

Goel and Tiwari (2004) intercropped mustard with potato, wheat, gram (*Cicer arietinum*), linseed, fenugreek and coriander or grown as a sole crop in Pantnagar, Uttar Pradesh, India and counted *L. erysimi* nymphs and adults from 10 randomly selected plants in each plot at weekly intervals from 89 to 117 days after sowing and aphid population (per 10 plants) was found lowest when mustard was intercropped with coriander, followed by linseed, fenugreek, gram, wheat and potato and the maximum aphid population was recorded when mustard was grown as a sole crop.

Meena and Lal (2004) reported the effect of cabbage intercropped with Lucerne, garlic, mustard, marigold and tomato on mustard aphid, *L. erysimi* incidence and found that Lucerne was the most effective followed by garlic, while mustard was the least effective intercrop in reducing the aphid population.

Saha *et al.* (2000) intercrops of linseed cv. Garima and Indian mustard (*Brassica juncea*) cv. Varuna and linseed cv. Garima and tomato cv. Pusa Ruby were infested with different species of insect pests of which the mustard aphid, *L. erysimi*, linseed gall midge, *Dasyneura lini*, black aphid, *Aphis craccivora*, and tomato fruit borer, *Helicoverpa armigera*, showed significant differences in infestation levels in various intercrop situations in Varanasi, Uttar Pradesh, India, during rabi season of 1996-97. However, there was a general downward trend in infestation level of different pests in intercrop combinations compared to their numbers in sole crops of preferred host. The intercrops were thus, found to be more suitable for natural suppression of pest populations.

Casagrade and Haynes (1976) pointed out an interesting potential for integration of plant resistant and polyculture practices. They compared damage by the cereal leaf beetle, *Oulema melanopus* L. in mixed and pure strands of resistant and susceptible wheat varieties. They reported that biological control was more effective in the mixed cropping of beetle resistant and beetle susceptible wheat varieties than in a pure strand of either one of those varieties on a region wide basis.

✍ Of the variety of factors that might be involved in the facilitative production principle, the one cited and perhaps the best documented is the reduction in pest attack frequently found in intercrops (Rich *et al.*, 1983). Earlier reviews found similar results (Kvass, 1978; Perkin, 1977; Lit singer and Moody, 1976; Dempester and Coaker, 1974; Nickel, 1973) that pests tend to be reduced in intercrops, although not by any means always. While these reviews tend to be concentrate on insects, there is also evidence that intercrops reduce nematode attack (Egunjobi, 1984; Catelli *et al.*, 1976; Khan *et al.*, 1969; Awal and Manger, 1967; Mc Beth and Taylor, 1944) and diseases (Moreno and Mora, 1984; Rheeneu *et al.*, 1981).

Franchise *et al.* (1978) found lower attack rates of *Spodoptera frugiperda* in maize + bean intercrop as compared to a maize monoculture. Vandermeer J.H. (1998) working in Kenya found the same pattern with the same pests in the same cropping system.

Andow (1991) found that polycultures had lower populations than monocultures and even then it occurred intermittently. Severe competition from the other plants in the polyculture might limit the ability of crop to compensate for pest injury and crop tolerance, or resistance. In an elegant experiment, Beach (1981) reasoned the plant "quality" might be affected by intercropping to such an extent that the individual host plant intercrops might be less desirable to their pests than individuals in monocultures. He found the *Acalymma vittatum* preferred cucumber leaves taken from monocultures to those taken from cucumber plants intercropped with tomatoes.

Dash *et al.* (1987) observed the highest pod infestation (45.80%) by *Helicoverpa armigera* in monoculture of arhar (*Cajanus cajan*) while the pod damage was the lowest (34.46%) when *C. cajan* was intercropped with black gram (*Vigna mungo*)

Prasad and Chand (1989) reported that intercropping of chickpea (*Cicer arietinum*) with barley, mustard and wheat suppressed number *H. armigera* by 59.56 and 47%, respectively. They concluded that barley, mustard and wheat are compatible crops for the intercrops of *C. arietinum*. In case of severe infestation in one crop, the financial return from the other crop is ensured.

Pawar (1993) showed that short duration pigeon pea grown adjacent to a strip- intercropped with sorghum suffered less damage by *H. armigera*. Similarly, Patnaik *et al.* (1989) observed the severest attack by *H. armigera* on sole cropped pigeon peas intercropped with groundnuts, mungbean (*Vigna radiata*), black gram (*Vigna mungo*) while it was the lowest in pigeon pea intercropped with finger millet.

Hossian *et al.* (1998) reported that intercropping exhibited a significant effect on pod borer infestation in chickpea in case of mid and late sowing dates. The dates of sowing irrespective of the intercropping displayed a significant effect on pod borer infestation with the early sowing contributing to the significant reduction of pod borer infestation. In case of late sowing, chickpea should be preferably intercropped with wheat to protect it against chickpea pod borer infestation ensuring higher yield.

In addition, the data suggested that pest injury is likely to exceed economic injury thresholds in polycultures than in monocultures. Again he claimed that absolute yield benefit in polyculture were higher than yields in monocultures.

Mahadevan and Chelliah (1986) reported that growing sorghum in association with cowpea (*Vigna unguiculata*) or lablab (*Lablab purpureus*) reduced the infestation of sorghum by the pyralid *Chilopteryx* in Tamil Nadu, India. On sorghum as a pure crop, 32% damage was recorded, as compared with lablab, respectively. The corresponding yields were 3609, 4652 and 4567 kg grain/ha, respectively.

Raymond and Alcazar (1983) claimed that potato plant grown in association with tomato, onion, maize, soybean or bean (*phaseolus*) had significantly less tuber damage from *Phthorimaea operculella* (zell.) than for potato alone. Sharma and Pandey (1993) carried out field studied in Navgaon, Rajasthan, India during 1984-86. The early maturing pigeon pea cv.UPAS-120 and the mid maturing cv.BDN-1 were intercropped with black gram (*V. mungo*) greengram (*V. radiata*), pearl millet and sorghum and the infestation by *Exelastisatomosa* and *Melanagromyza obtuse* was compared with that of pigeon pea grown as a sole crop. They found no market effect of intercropping on pest incidence. In the sole crop, insect infestation ranged between 42.5 to 52.66% in UPS-120 and between 57.0 to 62.16% in BDN-1.



✓ Bender *et al.* (1999) claimed that intercropping of cabbage (*Brassica oleracea* var. *capitata*) with Indian mustard (*Brassica juncea*) reduced pesticide applications and was evaluated over three cropping seasons. Insects were monitored in non-intercropped cabbage, cabbage plots surrounded by Indian mustard and the Indian mustard intercrop. Intercropping had no significant effect on the number of lepidopterous larvae in cabbages. Indian mustard did not appear to preferentially attract lepidopterous insects, but was highly attractive to hemipterans, especially harlequin bugs (*Murgantia histrionica*). In one season with heavy harlequin bug pressure, intercropping with Indian mustard eliminated two insecticide applications to cabbage.

Singh and Kothari (1997) reported that the mustard intercropped with aromatic plant species that could provide an environmentally safe method for aphid control, aphid infestation on a monocrop of *B. juncea* cv. *Rohini* was compared with infestation under intercropping with *Artemisia annua*, *Coriandrum sativum*, *Matricaria chamomilla* (*Chamomilla recutita*), *Foeniculum vulgare* and *Anethum sowa* and intercropping with *F. vulgare* resulted in a significantly lower aphid infestation.

✓ Monika *et al.* (2005) conducted an experiment to determine the effect of intercropping Indian mustard with potato, coriander (*Coriandrum sativum*), chickpea, wheat, linseed and fenugreek, on the incidence of the major insect pests, i.e. mustard aphid (*L. erysimi*), flea beetle (*Phyllotreta cruciferae*) and saw fly (*Athalia proxima*) and on the yield of mustard as sole crop and with intercrops. The lowest aphid population was recorded in mustard grown with coriander and the maximum population was observed on mustard as sole crop. Flea beetle incidence was minimum on mustard intercropped with linseed and maximum when sown with potato, while saw fly population was minimum on mustard sown with potato and maximum on mustard as sole crop. In monetary terms, the yield of mustard + linseed was maximum, while a minimum return was recorded for mustard + wheat.

✓ Sarker *et al.* (2007) found that the intercropped of mustard (*Brassica napus*, Var. *Bari Sarisha-7*) with onion (*Allium cepa* L.) and garlic (*Allium sativum* L.); these two medicinal as well as spice crops reduced the aphid population significantly. They also found that mustard blocks intercropped with garlic gave highest cost-benefit ratios (1:2.07 and 1: 2.96) than onion intercropped blocks and sole mustard blocks produced lowest cost-benefit ratios (1:1.65 and 1:2.06).

Rathore *et al.* (1980) conducted an intercropping experiment of maize with pulses and found that maize + black gram combination produced the highest grain yield.

Khehra *et al.* (1979) in an experiment found that black gram consistently gave higher yield when intercropped with maize, although the black gram as intercropped depressed the maize yield. Study of Krishna and Raikhelkar (1997) in maize- legumes intercropping systems found that maize +black gram (3.8t ha⁻¹), maize +green gram (3.6 t ha⁻¹) and maize + pegion pea (3.53 t ha⁻¹) gave significantly higher seed yield than other systems. Considering maize equivalent yield, maize + pegionpea (4.88 t/ha) and maize + black gram (4.66 t ha⁻¹), gave significantly higher equivalent yield than the other intercropping systems. Using land equivalent ratio (LER) as criteria, Bhuiyan (1981) examined mixed crop combinations of lentil, gram and soybean with wheat under different proportion and recorded the highest LER (1.47) in gram and wheat followed by lentil and wheat at 100:75, 100:50 and 100:25 values 1.37, 1.23 and 1.15, respectively.

These reviews of the literature represent that different intercropping systems had lowered insect infestation. Intercropping system has proven to show greater productivity and higher economic return than monocropping system. It can also reduce dependency on chemical insecticides and ensure a greater environmental protection. As intercropping has great scope in managing insect pests, it is therefore necessary to speculate the lower incidence of insect

pests, less dependency on chemical insecticides and pesticides and abundance of productivity and economics of intercropping systems.



Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from November 2013 to February 2014 to study the effect of intercropping on the incidence of mustard aphid. The details of the materials and methods that used to conduct the study are presented below:

3.1 Location

The study was conducted at the experimental farm of Sher-e-Bangla Agricultural University Bangladesh. The location of the experimental site was 24⁰ 09' N latitude and 24⁰ 26' E longitude and an elevation of 8.2 m from sea level (Anon, 2010).

3.2 Mustard and other crops for intercropping

The variety of mustard Tori-7 was selected for this experiment. This is locally produced and improved by the Bangladesh Agricultural Research Institute in the year of 2004. The plant height of this variety ranges 60-75 cm and the life cycle is 70 -75 days when cultivated in robi season.

3.3 The crops used for intercropping were

Coriander (*Coriandrum sativum* L.), fenugreek (*Trigonella foenum-graecum* L.), radhuni (*Trachyspermum roxburghianum* L.), black cumin (*Nigella sativa*), wheat (*Triticum aestivum* L.). Six treatments were conducted for this experiment. Treatments were,

Treatments	Crop Compositions
T ₁	Mustard intercropped with coriander (plate 2.)
T ₂	Mustard intercropped with Fenugreek (plate 3.)
T ₃	Mustard intercropped with radium (plate 4.)
T ₄	Mustard intercropped with black cumin (plate 5.)
T ₅	Mustard intercropped with wheat (plate 6.)
T ₆	Control (mustard sole)



Plate 1. Experimental plot



Plate 2. Intercropping of mustard with coriander



Plate 3. Intercropping of mustard with fenugreek



Plate 4. Intercropping of mustard with radhuni



Plate 5. Intercropping of mustard with black cumin



Plate 6. Intercropping of mustard with wheat

3.4 Collection of crop seeds

The mustard (*Brassica napus* var. Tori-7) was collected from Oilseed Research Center (ORC), Bangladesh Agricultural Research Institute (BARI), Gazipur. Wheat, fenugreek, black cumin, coriander and radhuni seeds were collected from Spices Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur.

3.5 Land Preparation

The experimental plot was ploughed in the first week of November 2013 with a power tiller, and was exposed to the sun for a week. The land was then harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for sowing of mustard and other crop seeds.

3.6 Experimental design and layout

The experiment was conducted considering six treatments and laid out in a Randomized Complete Block Design (RCBD). Each treatment was allocated randomly in three replications. Field trials were conducted during the winter season in the research field of Entomology Department, Sher-e-Bangla Agricultural University Campus. Mustard with local varieties of fenugreek, black cumin, wheat, coriander, radhuni was selected for intercropping. Altogether 3 blocks were prepared and 3 replications for each category fenugreek + mustard, black cumin + mustard and wheat + mustard, radhuni + mustard, coriander + mustard and only mustard were taken for this experiment. The unit plot size was 3.0 m x 2.0 m. The distance between plots and blocks were 1.0 m and 1.5 m, respectively and that of the row to row for mustard was 1.0 m. Similar distance was maintained when every seed was sown.

3.7 Fertilizers and manure application

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

Table 3.1. Dose and method of application of fertilizers in experimental plots

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

3.8 Date of sowing

The seeds of mustard and other intercropping crops were on 10 November 2013.

3.9 Cultural practices

After establishment of seedlings, all other intercultural operations such as, thinning, weeding, irrigation were accomplished whenever necessary for better growth and development of the mustard crop. Single irrigation was applied just once before flower initiation. Plots were provided with well arranged drainage facilities as prevention process of removing excess rain water if any. Weeding was done twice in the field to keep the plots free from weeds. The newly emerged weeds were uprooted carefully at the flowering stage by mechanical means.

3.10 Data collection

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

- Total number of infested plants/plot.
- Total number of leaves/plant
- Total number of infested leaves/plant



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- Total number of flower bud/plant
- Total number of infested flower bud/plant
- Total number of flower/plant
- Total number of infested flower/plant
- Total number of branch/ healthy plant
- Total number of branch/ infested plant
- Total number of siliqua/ healthy branch
- Total number of siliqua/ infested branch
- Total number of siliqua/ infested plant
- Total number of healthy siliqua/ infested plant
- Total number of infested siliqua/ infested plant
- Total number of seeds/ healthy siliqua
- Total number of seeds/ infested siliqua
- Wt. of seeds/ healthy plant
- Wt. of seeds/ infested plant
- Total seed wt./plot

3.11 Procedure of recording data

3.11. 1 Total number of infested plants/plot.

Total number of infested plants was counted from each replication from randomly selected five plants with five days interval.

3.11.2. Total number of leaves/plant

Total number of leaves was counted from randomly selected five plants of each replication with five days interval.

3.11.3. Total number of infested leaves/plant

Total number of infested leaves was counted from total number of leaves among selected five plants with five days interval.

3.11.4 Total number of flower bud/plant

Total number of flower bud was counted from each replication from randomly selected five plants with five days interval.

3.11.5 Total number of infested flower bud/plant

Total number of infested flower bud was counted from total number of flower bud among selected five plants with five days interval.

3.11.6 Total number of flower/plant

Total number of flower was counted from each replication from randomly selected five plants with five days interval.

3.11.7 Total number of infested flower/plant

Total number of infested flower was counted from total number of flower among selected five plants with five days interval.

3.11.8 Total number of branch/ healthy plant

Total number of branch/ healthy plant was counted from each replication from randomly selected five plants with five days interval.

3.11.9 Total number of branch/ infested plant

Total number of branch/ infested plant was counted from each replication from randomly selected five plants with five days interval.

3.11.10 Total number of siliqua/ healthy branch

Total number of siliqua/ healthy branch was counted from each replication from randomly selected five plants with weekly interval.

3.11.11 Total number of siliqua/ infested branch

Total number of siliqua/ infested branch was counted from each replication from randomly selected five plants with weekly interval.

3.11.12 Total number of siliqua/ infested plant

Total number of siliqua/ infested plant was counted from each replication from randomly selected five infested plants with weekly interval.

3.11.13 Total number of healthy siliqua/ infested plant

Total number of healthy siliqua was counted from each replication from randomly selected five infested plants with weekly interval.

3.11.14 Total number of infested siliqua/ infested plant

Total number of infested siliqua was counted from each replication from randomly selected five infested plants with weekly interval.

3.11.15 Total number of seeds/ healthy siliqua

Total number of seeds/ healthy siliqua was counted from each replication from randomly selected five healthy pods.

3.11.16 Total number of seeds/ infested siliqua

Total number of seeds/ infested siliqua was counted from each replication from randomly selected five infested pods.

3.11.17 Total seed wt. /plot

After threshing total gained seeds from each replication are weighted by electric machine.

3.11.18 Infestation Percentage

The following formula was used to calculate Infestation Percentage,

$$\text{Infestation percentage} = \frac{\text{Total infested value}}{\text{Total value}} \times 100$$

3.11.19 Percent reduction over control

The following formula was used to calculate percent reduction over control

$$\text{Percent reduction over control} = \frac{\text{Value of sole crop} - \text{Value of component crop (Mustard)}}{\text{Value of sole crop (Mustard)}} \times 100$$

3.12 Harvesting, threshing and cleaning

Mustard was harvested at the maturity (93 days of sowing without disturbing the other inter crops) was done manually from each plot. Fenugreeks, black cumin, wheat were harvested 102 days after sowing. Radhuni, coriander were harvested at same date respectively. Different harvested crops of each plot was bundled separately, properly tagged and brought to laboratory floor. Care was taken for harvesting, threshing and also cleaning of mustard and other intercrop crops. The seeds were cleaned and finally the weight was recorded and converted into per hectare yield. Mustard of each plot was threshed separately, cleaned, sun dried, weighed and packed. Radhuni was threshed carefully because of its light and small grain and threshed mechanically, cleaned, sun dried and weighed on those by mustard.

3.13 Statistical analyses

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



Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The results on the effect of intercropping systems with mustard with coriander, mustard with fenugreek, mustard with radhuni, mustard with black cumin, mustard with wheat compared to its monoculture mustard (control) on the incidence of mustard aphid. The results of the present study have been discussed and possible interpretations are presented in this chapter under the following sub headings:

4.1 Population trends of aphid on mustard

Aphids suck the cell sap from different parts of the mustard plant. The infestation trends of branches, leaves, flower buds and flower have been discussed below:

4.1.1 Trend of aphid infestation on mustard plant

Trends of aphid infested plants per plot are showed in (Figure 1.). It was observed that the lowest infestation was recorded in mustard with coriander (T₁) intercropping plots. The second lowest infestation was recorded in mustard with fenugreek (T₂) intercropping plots. Aphid infestation increased gradually with the time. On the other hand the highest aphid infested plant was found in T₆ (mustard sole) plot. Again the second highest infestation was found in mustard with wheat (T₅) intercropping plots.

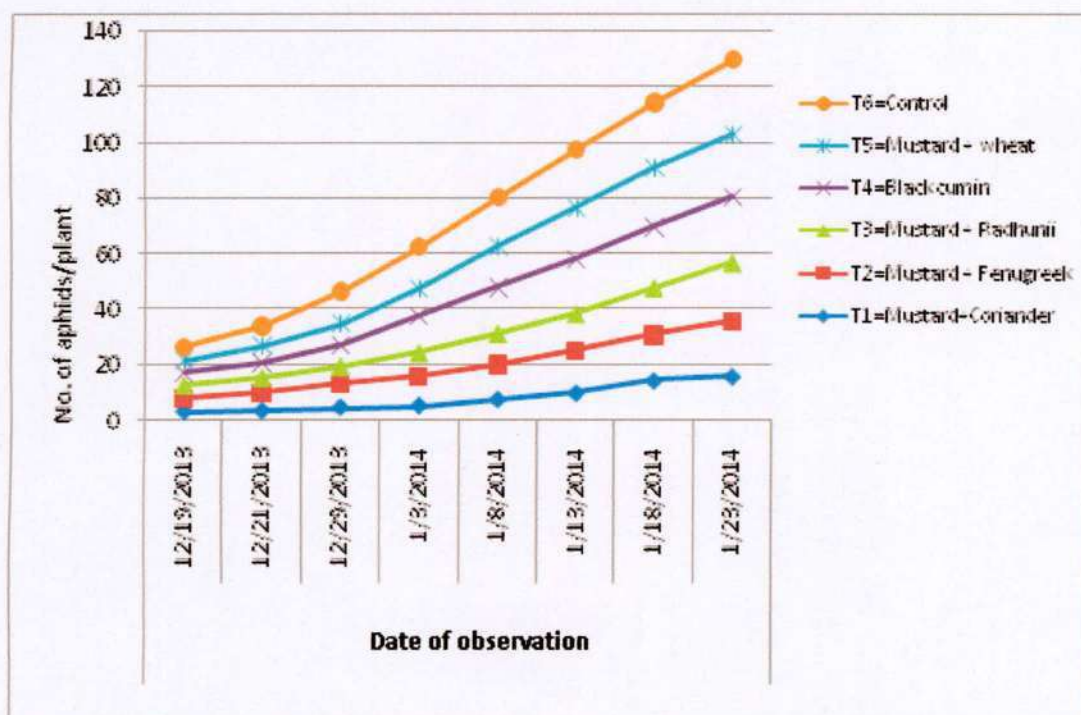


Figure 1. Population trends of aphid on mustard plants at different treatments.

4.1.1.1 Infestation at early stage

The results showed that the plots of mustard with different intercropped crops were greatly influenced the presence of aphid that harm the crop yield. The study showed that significant variation was observed in terms of affected plants in early stage by aphid at different treatments (Table 4.1). Highest infestation percentage per plot (16.22%) was recorded in the control (T_6) where no intercropping was used which was statistically different from all other intercropping plots. On the other hand, the percentage of aphid infestation per plot was significantly lower in all intercropping plots. The lowest percentage of infestation (7.77%) was found in mustard with coriander (T_1) and the second lowest result (10.44%) was found in mustard with radhuni (T_3), which were statistically and significantly different from other intercropping treatments. However mustard with wheat (12.00%) (T_5) and (12.22%) mustard with black cumin (T_4) having no statistical difference between them and finally (13.33%) mustard with fenugreek (T_2) plots were given similar results to the control plots.



Table 4.1. Effect of intercropping on the incidence of aphid at various stages of mustard

Treatments	Early stage	% decrease over sole crop	Mid stage	(%) decrease over sole crop	Late stage (%)	(%) decrease over sole crop	Mean (%)	(%) decrease over sole crop
T ₁	7.77 e	51.95 a	15.34 f	56.97 a	30.35 f	39.29 a	17.82 f	43.53 a
T ₂	13.33 b	17.73 d	25.56 d	28.26 c	36.01 e	27.97 b	24.97 d	26.48 c
T ₃	10.44 d	35.53 b	21.78 e	38.84 b	38.35 d	23.30 c	23.52 e	30.73 b
T ₄	12.22 c	24.63 c	33.56 b	5.77 e	45.67 b	8.66 e	30.48 b	10.24 e
T ₅	12.00 c	25.96 c	28.22 c	20.8 e	43.33 c	13.32 d	27.85 c	17.99 d
T ₆	16.22 a	----	35.67 a	----	50.00 a	----	33.96 a	----
CV%	4.30	9.37	3.28	7.23	1.33	4.43	1.35	4.23
LSD _{0.05}	0.94	5.49	1.59	4.10	0.98	1.88	0.65	2.12

Values in the column with the same letter(s) are not differ significantly by DMRT ($p = 0.05$).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found (51.95%) in mustard with coriander (T₅) intercropped combination and the lowest reduction of infestation was observed (17.73%) in mustard with fenugreek (T₂) intercropped system.

4.1.1.2 Infestation at mid stage

At mid stage statistically significant variation was observed for different intercropping patterns considering the plant infestation percentage per plot. Highest infestation percentage per plot (35.67%) was recorded in mustard sole crop (T₆) which was significantly higher than all other intercropping plots. On the other hand, aphid infestation percentage per plot was significantly lower in all intercropping plots. The lowest infestation percentage per plot (15.34%) was found in mustard with coriander (T₁) and the second lowest result (21.78%) was found in mustard with radhuni (T₃). So far mustard with fenugreek (25.56%), mustard with wheat (28.22%) and mustard with black cumin (33.56%) respectively having significant difference.

Additionally the percent decrease of infestation over sole crop, the highest reduction of infestation was found (56.97%) in mustard with coriander (T₁) intercropped combination and the lowest reduction of infestation was also observed (5.77%) in mustard with black cumin (T₄) and (20.8%) in mustard with wheat (T₅) respectively having no statistical difference between them.

4.1.1.3 Infestation at late stage

Different intercropping pattern showed statistically significant variation in late stage in case of percent plant infestation per plot. Highest infestation percentage per plot (50.00%) was recorded in mustard sole crop (T₆) which was statistically different from all other intercropping plots. On the other hand, aphid infestation percentage per plot was significantly lower in all intercropping plots. The lowest infestation percentage per plot (30.35%) was

found in mustard with coriander (T₁). The second lowest infestation (36.01%) was found in mustard with fenugreek (T₂) and then mustard with radhuni (38.35%), mustard with wheat (43.33%) and mustard with black cumin (45.67%), respectively having significant difference among them.

On the other hand in case of percent decrease of infestation over sole crop, the highest reduction of infestation was found (39.29%) in mustard with coriander (T₁) intercropped combination and lowest reduction of infestation was also observed (8.66%) in mustard with black cumin (T₄).

Statistically significant variation was also recorded as mean in case of total plant infestation percentage per plot. Highest infestation percentage per plot (33.96%) was recorded in mustard sole crop (T₆) which was statistically different from all other intercropping plots. On the other hand, aphid infestation percentage per plot was significantly lower in all intercropping plots. The lowest infestation percentage per plot (17.82%) was found in mustard with coriander (T₁). Then the second lowest result (23.52%) was found in mustard with radhuni (T₃). Then (24.97%) in mustard with fenugreek, (27.85%) in mustard with wheat (T₅) and (30.48%) in mustard with black cumin (T₄), respectively having significant difference.

On the other hand in case of percent decrease of infestation over sole crop, the highest reduction of infestation was found (43.53%) in mustard with coriander (T₁) intercropped combination and lowest reduction of infestation was also observed (10.24%) in mustard with black cumin (T₄), (17.99%), mustard with wheat (T₅), (26.48%), mustard with fenugreek (T₂) and (30.73%), mustard with radhuni (T₃), respectively were having significant difference among them.

✓ The result indicates that intercropping of mustard with spices reduced aphid infestation over sole crops in the field. This result agrees with the findings of Singh and Kothari (1997) who

observed that intercropping mustard with aromatic plants like coriander reduced aphid infestation on mustard over mono crop. It also supports the report of Monika *et al.* (2005) who recorded the lowest aphid population in mustard grown with coriander and the maximum population on mustard as sole crop.

4.1.2 Trend of aphid infestation on mustard leaves

Trends of aphid infested leaves per plant in different treatments are shown in Figure 2. It was observed that the lowest infestation result was recorded in mustard with coriander (T₁) intercropping plots. The second lowest result was recorded in mustard with radhuni (T₃) intercropping plots. Aphid infestation increased gradually by the time. On the other hand the highest aphid infestation plant was found in T₆ (mustard sole) plot. Again the second highest infestation result was found in mustard with wheat (T₅) intercropping plots.

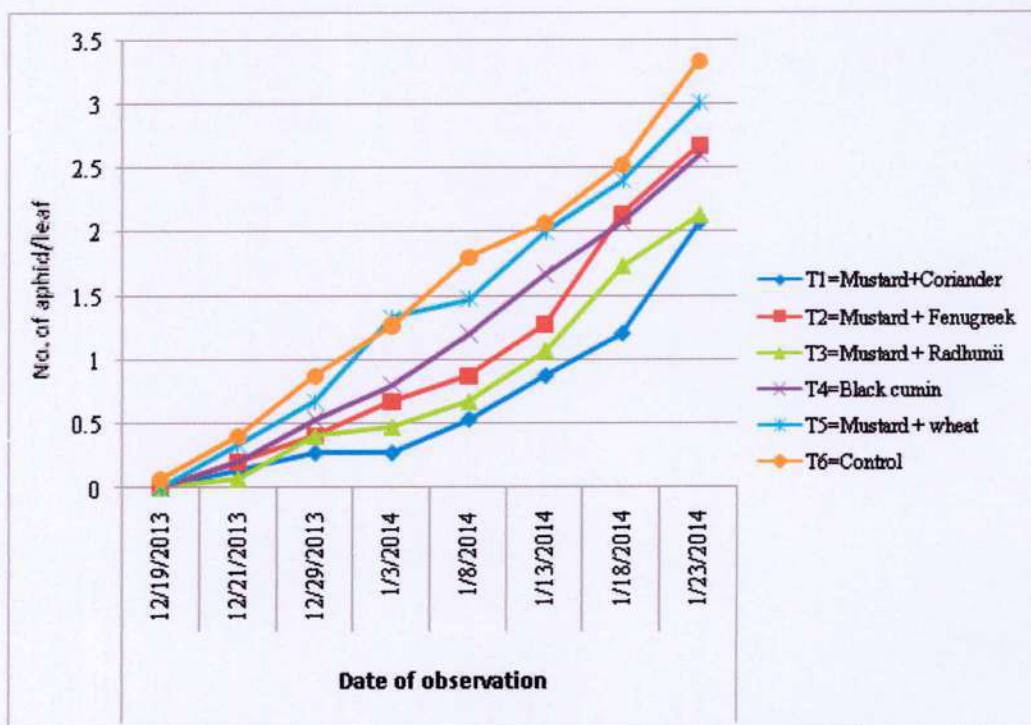


Figure 2. Population trends of aphid on mustard leaves at different treatments.

4.1.2.1 Infestation at early stage

Mustard plants with intercropped crops were greatly influenced the of aphid infestation. The data showed the significant variations in terms of affected plants in early stage by aphid at different treatments (Table 4.2). Highest percent of leaf infestation per plant (2.35%) was recorded in the control (T₆) and it was statistically different from all other intercropping plots. Additionally the infestation percentage of plots intercropped with wheat (1.67%) with the plots intercropped with black cumin (1.19%) showed significant differences between them. On the other hand, leaf infestation percentage per plant was significantly lower in all intercropping plots. The lowest leaf infestation percentage per plant (0.58%) was found in mustard with coriander (T₁), which is significantly different from other intercropping treatments.

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found (75.22%) in mustard with coriander (T₁) intercropped combination and the lowest reduction of infestation was also observed (28.82%) in mustard with wheat (T₅) plots then gradually increased in T₂ (59.06%) and T₃ (64.66%) intercropping system having no statistical difference between them.

4.1.2.2 Infestation at mid stage

The percent of leaf infestation showed significant variation at the mid stage of different intercropping patterns (Table 4.2). Highest leaf infestation percentage per plant (7.62%) was recorded in the control (T₆) which was which significantly higher than all other intercropping plots. In addition to that the leaf infestation percent was varied significantly between the intercropping patterns like mustard with wheat (6.66%) and mustard with black cumin (4.94%). Leaf infestation percentage per plant was significantly lower in all intercropping plots. The lowest Leaf infestation percentage per plant (1.99%) was found in mustard with



Table 4.2 Effect of intercropping on the incidence of mustard aphid at various stages in terms of percent leaf infestation **per plant** and percent decrease over sole crop

Treatments	Early stage	% decrease over sole crop	Mid stage	(%) decrease over sole crop	Late stage (%)	(%) decrease over sole crop	Mean (%)	(%) decrease over sole crop
T ₁	0.58 e	75.22 a	1.99 e	73.76 a	5.95 d	51.88 a	2.84 e	61.73 a
T ₂	0.95 cd	59.06 b	3.56 d	52.80 b	8.73 c	29.89 bc	4.41 c	40.87 c
T ₃	0.82 de	64.66 b	2.95 d	60.90 b	7.26 d	41.24 ab	3.67 d	50.44 b
T ₄	1.19 c	48.19 c	4.94 c	34.26 c	8.77 c	29.35 c	4.97 c	33.10 d
T ₅	1.65 b	28.82 d	6.66 b	18.90 d	10.64 b	14.42 d	6.32 b	17.89 e
T ₆	2.35 a	----	7.62 a	----	12.43 a	----	7.47 a	----
CV%	12.81	9.87	11.10	11.39	8.81	18.14	7.80	7.89
LSD_{0.05}	0.29	10.26	0.93	10.32	1.44	11.39	0.70	6.11

Values in the column with the same letter(s) are not differ significantly by DMRT (p = 0.05).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

coriander (T₁).The second lowest result (2.95%) was found in mustard with radhuni (T₃) followed by mustard with fenugreek (3.56%) having no statistical difference between them.

On the other hand in case of percent decrease of infestation over sole crop, the highest reduction of infestation was found (73.76%) in mustard with coriander (T₁) intercropped combination. The second highest result was observed in T₃ (60.90%) followed by T₂ (52.80%) having no statistical difference between them. Lowest reduction of infestation was also observed (18.90%) in mustard with wheat (T₅).

4.1.2.3 Infestation at late stage

Different intercropping pattern showed statistically significant variation in late stage in case of percent plant infestation per plot. Highest infestation percentage per plot (12.43%) was recorded in mustard sole crop (T₆) which was statistically and significantly varied from all other intercropping plots. Then mustard with wheat (10.64%).Again T₄ (8.77%) was identical to T₂ (8.73) have no statistical difference between them. On the other hand, aphid infestation percentage per plot was significantly lower in all intercropping plots. The lowest infestation percentage per plot was found in mustard with coriander (5.95%) followed by mustard with radhuni (7.26%) respectively, which have no statistical difference among them.

On the other hand In case of percent decrease of infestation over sole crop, the highest reduction of infestation was found in mustard with coriander (51.88%) intercropped combination and lowest reduction of infestation was also observed in mustard with wheat (14.42%).

Statistically significant variation was also recorded as mean in case of percent leaf infestation per plant. Highest leaf infestation per plant was recorded in mustard sole crop (7.47%) which was statistically different from all other intercropping plots. Then mustard with wheat (6.32%).Again, T₄ (4.97%) and T₂ (4.41%) have no statistical differences between them. On

the other hand, leaf infestation percentage was significantly lower in all intercropping plots. The lowest leaf infestation per plant (2.84%) was found in mustard with coriander (T₁) intercropping plots.

On the other hand In case of percent decrease of infestation over sole crop, the highest reduction of infestation was found in mustard with coriander (61.73%) intercropped combination and then T₃(50.44%), T₂(40.87%) and T₄(33.10%) respectively having significant difference among them. On the other hand, lowest reduction of infestation was also observed in mustard with wheat (17.89%).

The result indicates that intercropping of mustard with spices reduced aphid infestation over sole crops in the field. The result partially contradicts with the findings of Tiwari *et al.* (2005). They studied the effect of intercropping of mustard with potato, coriander (*Coriandrum* spp, chickpea, wheat, linseed and fenugreek, on the incidence of the major insect pests, i.e. mustard aphid (*Lipaphis erysimi*), flea beetle (*Phyllotreta cruciferae*) and saw fly (*Athalia proxima*) and on the yield of mustard as sole crop and intercrops. They found that the lowest aphid population was recorded in mustard grown with coriander and the maximum population was observed on mustard as sole crop.

4.1.3 Trends of aphid infestation on flower buds of mustard

Trends of aphid infested flower buds per plant are showed in Figure 3. It was observed that the lowest infestation result was recorded in mustard with radhuni (T₃) intercropping plots. Again the second lowest result was recorded in mustard with coriander (T₁) intercropping plots. Aphid infestation increased gradually. On the other hand the highest aphid infested plant was found in mustard with black cumin (T₄) plots. Again the second highest infestation result was found in mustard with fenugreek (T₂) intercropping plots.

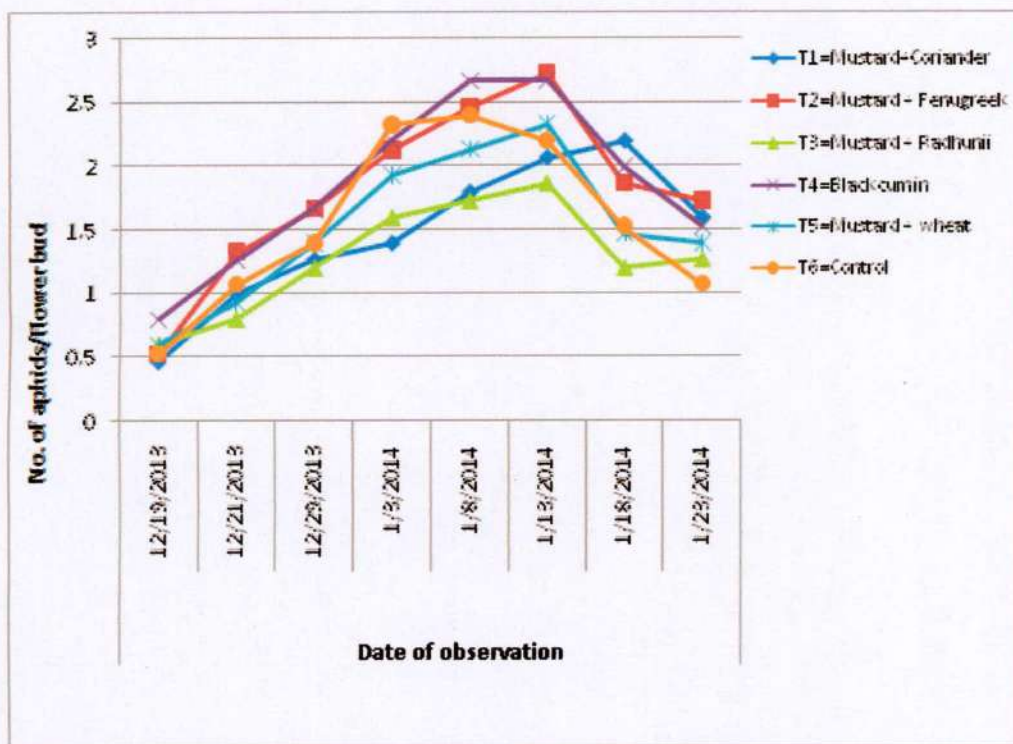


Figure 3. Trends of aphid infestation on flower buds at different treatments.

4.1.3.1 Infestation at early stage

Mustard plants with intercropped crops were greatly influenced by the presence of aphid that harms flower buds. The data from Table 4.3 showed that significant variation was observed in terms of affected plants in early stage by aphid at different treatments. Highest flower bud infestation percentage per plant was recorded in mustard sole crop (23.14%) which was identical to mustard with black cumin (22.19%) and was significantly different from all other intercropping plots. Then mustard with wheat (20.59%), mustard with fenugreek (18.88%) and mustard with radhuni (17.15%) respectively were having significant difference among them. On the other hand, flower bud infestation percentage per plant was significantly lower in all intercropping plots. The lowest flower bud infestation percentage per plant was found

in mustard with coriander (13.84%) which was significantly and statistically different from other intercropping treatments.

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found in mustard with coriander (40.21%) and then mustard with radhuni (25.87%), mustard with fenugreek (18.37%) and mustard with wheat (11.03%) intercropped combination respectively having significant difference among them. Again the lowest reduction of infestation was also observed in mustard with black cumin (4.11%), which was significantly and statistically different from other intercropping treatments.

4.1.3.2 Infestation at mid stage

At mid stage statistically significant variation was observed for different intercropping patterns in case of percent flower bud infestation. Highest flower bud infestation percentage per plant was recorded in mustard sole crop (43.21%) which was which significantly higher than all other intercropping plots. Then mustard with black cumin (38.46%), mustard with wheat (36.52%), mustard with fenugreek (31.85%) and mustard with radhuni (27.08%) respectively were having significant difference among them. On the other hand, flower bud infestation percentage per plant was significantly lower in all intercropping plots. The lowest flower bud infestation percentage per plant was found in mustard with coriander (20.81%) which was significantly and statistically different from other intercropping treatments.

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found in mustard with coriander (51.83%) and then mustard with radhuni (37.32%), mustard with fenugreek (26.34%) and mustard with wheat (15.51%) intercropped combination respectively having significant difference among them. Again the lowest reduction of infestation was also observed in mustard with black cumin (10.97%) which was significantly and statistically different from other intercropping treatments.

4.1.3.3 Infestation at late stage

Different intercropping pattern showed statistically significant variation in late stage in case of flower bud infestation per plant. The lowest flower bud infestation percentage per plant (36.64%) was found in mustard with coriander (T₁) which was significantly and statistically different from other intercropping treatments. On the contrary, the highest flower bud infestation per plant was recorded in control (51.13%) followed by 45.55% in T₄ having significant difference between them. Again, mustard with wheat and mustard with fenugreek (45.07) have no statistical difference between them and then mustard with radhuni (43.05%) respectively. On the other hand, flower bud infestation percentage per plant was significantly lower in all intercropping plots.

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found (28.36%) in mustard with coriander (T₁) and then (15.81%) mustard with radhuni (T₃). Again (11.85%) mustard with fenugreek (T₂) and (10.92%) mustard with wheat (T₅) intercropped combination respectively having no statistical difference between them. Again the lowest reduction of infestation was also observed (6.75%) in mustard with black cumin (T₄) which was significantly and statistically different from other intercropping treatments.

Table 4.3 Effect of intercropping on the incidence of mustard aphid at various stages in terms of percent flower bud infestation per plant and percent decrease over sole crop

Treatments	Early stage	% decrease over sole crop	Mid stage	% decrease Over sole crop	Late stage	% decrease over sole crop	Mean	% decrease over sole crop
T ₁	13.84 e	40.21 a	20.81 f	51.83 a	36.64 e	28.36 a	23.76 f	39.32 a
T ₂	18.88 c	18.37 c	31.85 d	26.34 c	45.07 c	11.85 c	31.93 d	18.46 c
T ₃	17.15 d	25.87 b	27.08 e	37.32 b	43.05 d	15.81 b	29.09 e	25.72 b
T ₄	22.19 a	4.11 e	38.46 b	10.97 e	47.68 b	6.75 d	36.11 b	7.78 e
T ₅	20.59 b	11.03 d	36.52 c	15.51 d	45.55 c	10.92 c	34.22 c	12.62 d
T ₆	23.14 a	----	43.21 a	----	51.13 a	----	39.16 a	----
CV%	2.95	13.60	2.53	7.05	2.04	13.36	1.36	6.02
LSD _{0.05}	1.04	5.10	1.52	3.77	1.66	3.71	0.80	2.36

Values in the column with the same letter(s) are not differ significantly by DMRT ($p = 0.05$).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

Statistically significant variation was also recorded in case of percent flower bud infestation per plant. Highest flower bud infestation per plant (39.16%) was recorded in mustard sole crop (T₆) which was statistically different from all other intercropping plots. Then 36.11% infestation was found in mustard with black cumin (T₄), 34.22% in mustard with wheat (T₅), 31.93% in mustard with fenugreek (T₂) and 29.09% in mustard with radhuni (T₃) having significant difference among them. On the other hand, flower bud infestation percentage per plant was significantly lower in all intercropping plots. The lowest flower bud infestation percentage per plant (23.76%) was found in mustard with coriander (T₁) which was significantly and statistically different from other intercropping treatments. The result indicates that intercropping of mustard with spices reduced aphid infestation over sole crops in the field.

In case of percent decrease of infestation over sole crop the highest reduction of flower bud infestation was found (39.32%) in mustard with coriander (T₁) intercropped combination and then (25.72%) mustard with radhuni (T₃), (18.46%) mustard with fenugreek (T₂) and (12.62%) mustard with wheat (T₅) intercropped combination respectively having significant difference among them. On the other hand, the lowest reduction of infestation was also observed (7.78%) in mustard with black cumin (T₄), which was significantly and statistically different from other intercropping treatments.

4.1.4 Trends of aphid infestation on flowers of mustard

Trends of aphid infested flowers per plant are showed in (Figure 4.). It was observed that the lowest infestation result was recorded in mustard with coriander (T₁) intercropping plots. Again the second lowest result was recorded in mustard with radhunii (T₃) intercropping plots. The aphid infestation increased gradually. On the other hand the highest aphid infested plant was found in mustard with black cumin (T₄) plot. Again the second highest infestation result was found in mustard with fenugreek (T₂) intercropping plots.

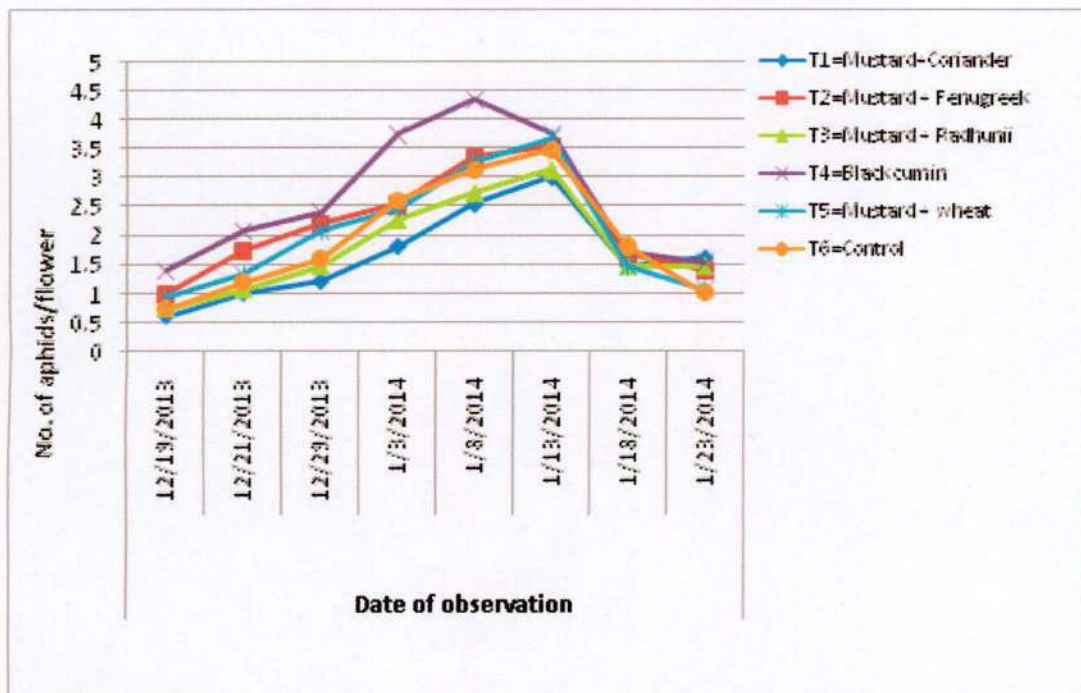


Figure 4. Trends of aphid infestation on flowers of mustard at different treatments.

4.1.4.1 Infestation at early flowering stage

Mustard plants with intercropped crops were greatly influenced by the presence of aphid that harms mustard flowers. The data from (Table 4.4) showed that significant variation was observed in terms of affected plants in early stage by aphid at different treatments. Highest flower infestation percentage per plant (25.81%) was recorded in mustard sole crop (T_6) followed by (24.46%) mustard with black cumin (T_4) which was significantly higher than all other intercropping plots. Then (20.13%) mustard with wheat (T_5) and (19.42%) mustard with radhuni (T_3) had shown the same statistical result but having significant difference between them. Again, (16.70%) mustard with fenugreek was showed very close result to mustard with coriander (T_1) intercrop plot. On the other hand, flower infestation percentage per plant was significantly lower in all intercropping plots. The lowest flower bud infestation percentage per plant (10.43%) was found in mustard with coriander (T_1) which was significantly and statistically different from other intercropping treatments.

In case of percent decrease of infestation over sole crop the highest reduction of flower infestation was found (59.56%) in mustard with coriander (T₁) and then (35.30%) mustard with fenugreek (T₂) respectively. Again, (24.83%) mustard with radhuni (T₃) and (21.97%) mustard with wheat (T₅) intercropped combination had shown same result statistically but significant difference between them. On the other hand, the lowest reduction of flower infestation was observed (5.32%) in mustard with black cumin (T₄), which was significantly and statistically different from other intercropping treatments.

Table 4.4 Effect of intercropping on the incidence of mustard aphid at various stages in terms of percent flower infestation per plant and percent decrease over sole crop

Treatments	Early stage	% decrease over sole crop	Mid stage	% decrease Over sole crop	Late stage	% decrease over sole crop	Mean	% decrease over sole crop
T ₁	10.43 d	59.56 a	14.93 e	49.35 a	27.78 e	35.44 a	17.72 e	45.94 a
T ₂	16.70 c	35.30 b	18.31 d	37.90 b	37.03 c	13.92 c	24.01 d	26.75 b
T ₃	19.42 b	24.83 c	19.33 d	34.45 b	30.95 d	28.08 b	23.23 d	29.13 b
T ₄	24.46 a	5.32d	24.80 b	15.92 d	39.75 b	7.62 d	29.67 b	9.50 d
T ₅	20.13 b	21.97 c	22.86 c	22.53 c	38.27 bc	11.05cd	27.09 c	17.37 c
T ₆	25.81 a	----	29.49 a	----	43.06 a	----	32.78 a	----
CV%	3.90	9.33	4.21	10.18	2.46	9.57	2.37	6.98
LSD _{0.05}	1.38	5.16	1.65	6.14	1.62	3.47	1.11	3.38

Values in the column with the same letter(s) are not differ significantly by DMRT ($p = 0.05$).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

4.1.4.2 Infestation at mid flowering stage

At mid stage statistically significant variation was observed for different intercropping patterns in case of percent flower infestation. Highest flower infestation percentage per plant (29.49%) was recorded in mustard sole crop (T₆) which was significantly higher than all other intercropping plots. Then (24.80%) mustard with black cumin (T₄), (22.86%) mustard with wheat (T₅) respectively having significant difference among them. (19.33%) mustard with radhuni (T₃) and (18.31%) mustard with fenugreek (T₂) had shown the same statistical result and but significantly different. On the other hand, flower infestation percentage per plant was significantly lower in all intercropping plots. The lowest flower infestation percentage per plant (14.93%) was found in mustard with coriander (T₁) which was significantly and statistically different from other intercropping treatments.

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found (49.35%) in mustard with coriander (T₁) intercropped combination. Again, (37.90%) mustard with fenugreek (T₂) and (34.45%) mustard with radhuni (T₃) have shown the same statistical result but having significant difference between them and (22.53%) mustard with wheat (T₅) and then mustard with black cumin (T₄). On the other hand, the lowest reduction of infestation was also observed (15.92%) in mustard with black cumin (T₄), which was significantly and statistically different from other intercropping treatments.

4.1.4.2 Infestation at late flowering stage

Different intercropping pattern showed statistically significant variation in late stage in case of flower infestation per plant. Highest flower infestation per plant (43.06%) was recorded in mustard sole crop (T₆) which was statistically and significantly different from all other intercropping plots. Again (39.75%) mustard with black cumin (T₄) closely followed by (38.27%) mustard with wheat (T₅) intercropping treatment having significant difference

between them. Then, (37.03) mustard with fenugreek (T₂) and (30.95%) mustard + radhuni (T₃) respectively were having significant difference between them. On the other hand, flower infestation percentage per plant was significantly lower in all intercropping plots. The lowest flower infestation percentage per plant (27.78%) was found in mustard with coriander (T₁) which was significantly and statistically different from other intercropping treatments.

In case of percent decrease of infestation over sole crop the highest reduction of flower infestation was found (35.44%) in mustard with coriander (T₁) and (28.08%) mustard with radhuni (T₃) respectively. Again, (13.92%) mustard with fenugreek (T₂) closely followed by (11.05%) mustard with wheat (T₅) intercropped combination having significant difference between them. On the other hand, the lowest flower reduction of infestation was also observed (7.62%) in mustard with black cumin (T₄) which was significantly and statistically different from other intercropping treatments.

Statistically significant variation was also recorded as mean in case of percent flower infestation per plant. Highest flower infestation per plant (32.78%) was recorded in mustard sole crop (T₆) which was statistically and significantly different from all other intercropping plots. Then (29.67%) mustard with black cumin (T₄) and (27.09%) mustard with wheat (T₅). Again (24.01%) mustard with fenugreek (T₂) and (23.23%) mustard with radhunii (T₃) have shown the same statistical result but having significant difference between them. On the other hand, flower infestation percentage per plant was significantly lower in all intercropping plots. The lowest flower infestation percentage per plant (17.72%) was found in mustard with coriander (T₁) which was significantly and statistically different from other intercropping treatments.

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found (45.94%) in mustard with coriander (T₁) intercropped combination. Again (29.13%) mustard with radhunii (T₃) and (26.75%) mustard with fenugreek (T₂) have shown

the same statistical result but significantly different. Then (17.37%) mustard with wheat (T₅) intercropped combination which performed very close result to mustard with black cumin (T₄). On the other hand, the lowest reduction of infestation was also observed (9.50%) in mustard with black cumin (T₄) which was significantly and statistically different from other intercropping treatments.

The result indicates that intercropping of mustard with spices reduced aphid infestation over sole crops in the field. The similar result was found by Goel and Tiwari (2004) who worked on mustard with potato, wheat, gram (*Cicer arietinum*), linseed, fenugreek and coriander and counted aphid population. He found the lowest aphid number when mustard was intercropped with coriander, followed by linseed, fenugreek, gram, wheat and potato and the maximum aphid population was recorded when mustard was grown as a sole crop.

4.5 Effect of intercropping on number of branch per plant

4.5.1 Total number of branch per healthy plant

Significant variation was observed in terms of number of branches per healthy plant at different intercroppings (Table 4.5). The highest number of branches per plant (5.35) was recorded in mustard sole crop (T₆) followed by (5.08) in mustard with black cumin (T₄) which were statistically similar but significantly different and again (4.69) in mustard with fenugreek (T₂) closely followed by (4.56) in mustard with radhunii (T₃) which was identical to in mustard with coriander (4.42) intercropping system respectively. On the other hand, the lowest number of branch per plant (4.26) was recorded in mustard with wheat (T₅) intercropped combinations. Although sole crops had the highest aphid infestation, number of branch was higher due to lack competition with other crops.

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found (20.20) in mustard with wheat (T₅) closely followed by (17.31) in mustard with

coriander intercropped combination respectively which were significantly greater than all other intercrop treatment results. On the other hand, the lowest reduction of infestation was also observed (5.04) in mustard with black cumin (T₄).

Table 4.5 Effect of intercropping on the incidence of mustard aphid in terms of branch per plant and decrease over sole crop

Treatments	Branch/Healthy Plant		Branch/Infested Plant	
	Branch Number	Decrease over sole crop	Branch Number	Decrease over sole crop
T ₁	4.42 bc	17.31 ab	4.39 d	19.16 a
T ₂	4.69 b	12.33 c	5.05 bc	7.23 bc
T ₃	4.56 bc	14.77 bc	4.80 c	11.89 b
T ₄	5.08 a	5.04 d	5.18 ab	5.01 c
T ₅	4.26 c	20.20 a	4.88 bc	10.47 b
T ₆	5.35 a	----	5.46 a	----
CV%	3.33	16.26	3.49	23.74
LSD _{0.05}	0.29	4.26	0.32	4.81

Values in the column with the same letter(s) are not differ significantly by DMRT (p = 0.05).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

4.5.2 Total number of branch per infested plant

The data in (Table 4.5.) demonstrated that significant variation was existed in case of aphid infested branch per plant under different treatments. The highest number of aphid infested branches per plant (5.46) was recorded from mustard sole plot (T₆) followed by (5.18) in mustard with Black cumin (T₄) which were statistically closer but significantly different and higher than all other intercrop treatments. Again, (5.05) in mustard with fenugreek (T₂) followed by (4.88) in mustard with wheat (T₅) which were statistically similar but

significantly different and then (4.80) in mustard with radhuni (T₃) respectively. On the other hand, the lowest number of aphid infested branch per plant (4.39) was recorded from mustard with coriander (T₁) crop combination which was statistically similar to all other.

In case of percent decrease of infestation over sole crop the highest reduction of infestation was found (19.16) in mustard with coriander (T₁) which was significantly greater than all other intercrop treatment results. Again, second highest found at (11.89) in mustard with radhuni (T₃) followed by (10.47) in mustard with wheat (T₅). On the other hand, the lowest reduction of infestation was also observed (5.01) in mustard with black cumin (T₄), which was significantly and statistically different from other intercropping treatments.

4.6 Effect of intercropping on siliqua per branch

4.6.1 Number of siliqua per healthy branch

4.6.1.1 Number of siliqua at early stage

Mustard plants with intercropped crops were greatly influenced by aphid. The result showed the significant variation of siliqua formation at different treatments in early stage Table 4.6.1. Highest number of siliqua per branch (25.18) was counted in mustard with coriander (T₁) intercropping system which was statistically similar to other treatments except mustard with radhuni (22.48). However the lowest number of siliqua per branch (21.59) was estimated in the control treatment.

In case of percent increase of siliqua formation over the control the highest increasing of siliqua formation was found in mustard with radhuni (18.43) followed by in mustard with coriander (16.64) intercropping combination. On the other hand the lowest increasing of siliqua formation was also observed in mustard with black cumin (4.28) intercropped system.

Table 4.6.1 Effect of intercropping on the incidence of mustard aphid at various stages in terms of siliqua per healthy branch and increase over sole crop

Treatments	Early Stage	% increase over sole crop	Late stage	% increase over sole crop	Mean	% increase over sole crop
T ₁	25.18 a	16.64 ab	27.57 a	21.79 a	26.38 a	19.25 a
T ₂	23.65 c	9.54 c	24.47 c	8.11 d	24.06 c	8.79 c
T ₃	22.48 a	18.03 a	26.50 c	17.11 b	26.00 a	17.54 a
T ₄	22.52 d	4.28 d	23.27 d	2.70 e	22.89 d	3.45 d
T ₅	24.45 b	13.22 b	25.75 b	13.73 c	25.10 b	13.47 b
T ₆	21.59 e	-----	22.67 d	-----	22.13 e	-----
CV%	1.56	15.09	1.72	13.82	1.56	14.05
LSD_{0.05}	0.67	3.51	0.78	3.30	0.70	3.31

Values in the column with the same letter(s) are not differ significantly by DMRT (p = 0.05).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

Siliqua number at late stage

Mustard plants with intercropped crops were greatly influenced by aphid. The data from (Table 4.6.1) in late stage showed that significant variation was observed in terms of siliqua formation at different treatments. Highest number of siliqua per branch (27.57) was recorded in mustard with coriander (T₁) intercropping system which were statistically and significantly greater than all other intercropping treatments. On the other hand, the lowest number of siliqua per branch (22.67) in mustard sole crop which was statistically similar to (23.27) in mustard with black cumin (T₄) and then (24.47) in mustard with fenugreek (T₂) followed by (26.50) in mustard with radhuni (T₃) intercropping system respectively.

In case of percent increasing of siliqua formation over the control the highest increasing of siliqua formation was found in mustard with coriander (21.79) which was statistically and significantly different from all other treatment results. On the other hand the lowest increasing of siliqua formation was also observed in mustard with black cumin (2.70) intercropped system.

Table 4.6.1 shows the average number of siliqua per plant (26.38) was recorded in mustard with coriander (T₁) intercropping system which was significantly greater than all other intercropping treatments. But it is similar to mustard with radhuni (26.00) intercropping system. The lowest number of infested siliqua per plant (22.13) was recorded in the control.

In case of percent increase of siliqua formation over sole crop the highest increasing of siliqua formation was found (19.25) in mustard with coriander (T₁) and which was statistically similar to (17.54) in mustard with radhuni (T₃) intercropped combination. On the other hand the lowest increasing of siliqua formation was found (3.45) in mustard with black cumin (T₄) intercropping system.

The results agree with the findings of Monika *et al.* (2005) who studied the effect of intercropping of Indian mustard with coriander and other crops and the incidence of the major insect pest, i.e. aphid and found the lowest aphid population in mustard grown with coriander and the maximum population was observed on mustard as sole crops.

4.6.2 Number of siliqua per infested branch

4.6.2.1 Siliqua number at early stage

Mustard plants with intercropped crops were greatly influenced by aphid. The data from Table 4.6.2 in early stage showed that significant variation was observed in terms of siliqua formation at different treatments. Highest number of siliqua per branch (24.93) was recorded in mustard with coriander (T₁) intercropping plot which were statistically different and significantly greater than all other intercropping treatments. On the other hand, the lowest

number of siliqua per branch (16.47) was recorded in (T₆) mustard (control) which was closely followed by (17.53) in mustard with black cumin (T₄) and then (17.73) in mustard with wheat (T₅) which was followed by (18.33) in mustard with fenugreek (T₂) intercropping systems respectively.

In case of percent increase of siliqua formation over sole crop the highest increasing of siliqua formation was found (51.33) in mustard with coriander (T₁) which was statistically different and significantly different from all other intercropping treatments. On the other hand the lowest increasing of siliqua formation was also observed (6.48) in mustard with black cumin (T₄) followed by (7.73) in mustard with wheat (T₅) and (11.28) in mustard with fenugreek (T₂) intercropping systems respectively.

Table 4.6.2 Effect of intercropping on the incidence of mustard aphid at various stages in terms of siliqua per infested branch and increase over sole crop

Treatments	Early Stage	Increase over sole crop	Late Stage	Increase over sole crop	Mean	Increase over sole crop
T ₁	24.93 a	51.53 a	26.53 a	38.18 a	25.73 a	44.31 a
T ₂	18.33 c	11.28 c	21.41 c	11.54 c	19.87 c	11.41 c
T ₃	20.80 b	26.35 b	23.20 b	20.84 b	22.00 b	23.35 b
T ₄	17.53 cd	6.48 c	19.80 d	3.12 d	18.66 d	4.66 d
T ₅	17.73 c	7.73 c	21.93 c	14.24 c	19.83 c	11.22 c
T ₆	16.47 d	-----	19.20 d	-----	17.83 d	----
CV%	3.42	21.47	2.37	16.50	2.54	17.23
LSD _{0.05}	1.20	8.36	0.95	5.46	0.96	6.16

Values in the column with the same letter(s) are not differ significantly by DMRT (p = 0.05).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

4.6.2.2 Siliqua number at late stage

Mustard plants with intercropped crops were greatly influenced by aphid. The data from Table 4.6.2 in late stage showed that significant variation was observed in terms of siliqua formation at different treatments. Highest number of siliqua per branch (26.53) was recorded in mustard with coriander (T₁) intercropping system which were statistically and significantly different than all other intercropping treatments. On the other hand, the lowest number of siliqua per branch (19.20) in mustard sole crop was statistically similar to (19.80) in mustard with black cumin (T₄) then (21.41) in mustard with fenugreek (T₂) and (21.93) in mustard with wheat (T₅) respectively.

In case of percent increasing of siliqua formation over sole crop the highest increasing of siliqua formation was found (38.18) in mustard with coriander (T₁) which was statistically different and significantly greater than all other treatment results. On the other hand the lowest increasing of siliqua formation was also observed (3.12) in mustard with black cumin (T₄) and then (11.54) in mustard with fenugreek (T₂) followed by (14.24) in mustard with wheat (T₅) intercropped system respectively.

Results from mean in (Table 4.6.2) showed that the highest number of siliqua/plant (25.73) was recorded in mustard with coriander (T₁) intercropping system which were statistically different and significantly greater than all other intercropping treatments. On the other hand the lowest number of infested siliqua per plant (17.83) was recorded in sole crop mustard (T₆). It was also observed that the statistically similar (18.66) result was found in treatments (T₄) which was combined by mustard with black cumin inter cropping plot. Similar trend was observed (19.83) in mustard with wheat (T₅) and (19.87) in mustard with fenugreek (T₂) intercropping system respectively.

In case of percent increase of siliqua formation over sole crop the highest increasing of siliqua formation was found (44.31) in mustard with coriander (T₁) and which was

statistically different and significantly greater than all other intercropping system results. On the other hand the lowest increasing of siliqua formation was found (4.66) in mustard with black cumin (T₄) intercropping system then (11.22) in mustard with wheat (T₅) and (11.41) in mustard with fenugreek intercropping systems respectively.

The similar result was found by Goel and Tiwari (2004) and they reported that aphid population was lowest when mustard was intercropped with coriander followed by radhunii and other intercrops and the maximum aphid population was recorded when mustard was grown as a sole crop.

4.7 Siliqua infestation per infested plant

4.7.1 Total infested siliqua

Mustard plants with intercropped crops were greatly influenced by aphid. The data from Table 4.7 showed that significant variation was observed in terms of total infested siliqua number at different treatments. The highest number of infested siliqua per plant (93.35) was recorded in mustard sole crop (T₆) intercropping system which was closely followed by statistically similar (89.42) in mustard with black cumin (T₄) and then (87.86) in mustard with fenugreek (T₂) intercropping system respectively. On the other hand the lowest number of infested siliqua per plant (76.87) was recorded in mustard with Coriander (T₁) and which was statistically similar to (79.12) in mustard with radhuni(T₃).

Table 4.7 Effect of intercropping on the incidence of mustard aphid in terms of percent siliqua infestation per infested plant and percent decrease over sole crop

Treatments	Infested siliqua	Total siliqua	percent siliqua infestation	Decrease over sole crop
T ₁	76.87 d	118.00 a	65.13 d	33.57 a
T ₂	87.86 b	99.95 d	87.88 b	10.39 c
T ₃	79.12 d	114.8 b	69.01 d	29.57 a
T ₄	89.42 ab	96.60 e	92.54 b	5.68 c
T ₅	83.58 c	109.4 c	76.38 c	22.11 b
T ₆	93.35 a	95.17 e	98.08 a	-----
CV%	2.76	1.46	3.25	13.50
LSD _{0.05}	4.27	2.81	4.81	5.15

Values in the column with the same letter(s) are not differ significantly by DMRT (p = 0.05).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

4.7.2 Total number of siliqua

Mustard plants with intercropped crops were greatly influenced by aphid. The data from Table 4.7 showed that significant variation was observed in terms of total siliqua number at different treatments. The highest number of siliqua per plant (118.00) was recorded in mustard with coriander (T₁) and then (114.8) in mustard with radhunii (T₃) intercropping treatments which were statistically different and significantly greater than all other treatments. On the other hand the lowest number of siliqua per plant (95.17) was recorded in mustard sole crop (T₆) followed by statistically similar (96.60) in mustard with black cumin (T₄) intercropping treatment.

4.7.3 Percent siliqua infestation

Table 4.7 shows that the highest number of siliqua infestation percentage (98.08%) was recorded in mustard sole crop (T₆) which was statistically different and significantly greater than all other intercropping treatments. On the other hand the lowest number of infested

siliqua per plant (65.13%) was recorded in mustard with coriander (T₁). It was also observed that the statistically similar (69.01%) result was found in treatments (T₃) which was combined by mustard with radhuni inter cropping system.

In case of percent decrease of siliqua infestation over sole crop the highest reduction was found (33.57%) in mustard with coriander (T₁) intercropping treatment. It was also observed that the statistically similar (29.57%) result was found in treatments (T₃) which was combined by mustard with radhuni. On the other hand the lowest increasing of siliqua formation was found (5.68%) in mustard with black cumin (T₄) intercropping system followed by statistically similar (10.39%) in mustard with fenugreek (T₂) intercropping treatment.

4.8 Effect of intercropping on seed per siliqua

4.8.1 Total seed number per healthy siliqua

Table 4.8 shows that significant variation was observed in terms of Total seed per healthy siliqua at different treatments. The highest number of seed per siliqua (23.70) was recorded in mustard with coriander (T₁) followed by (23.30) in mustard with wheat (T₅) and closely followed by (22.80) in mustard with radhunii (T₃) respectively which were statistically different and significantly greater than all other intercropping treatments. On the other hand the lowest number of seed per siliqua (17.03) was recorded in mustard sole crop (T₆). It was also observed that the statistically similar (18.60%) result was found in treatments (T₄) which was combined by mustard with black cumin intercropping system.

In case of percent increase of seed per siliqua over sole crop the highest increasing was found (39.06) in mustard with coriander (T₁) intercropping treatment. It was also observed that the statistically similar (36.75) result was found in treatments (T₅) which was combined by mustard with wheat which was closely followed by (33.78) in mustard with radhuni (T₃)

intercropping treatment. On the other hand the lowest increasing of siliqua formation was found (9.26) in mustard with black cumin (T₄) intercropping system.

Table 4.8 Effect of intercropping on the incidence of mustard aphid in terms of seed per siliqua and increase over sole crop

Treatments	Healthy siliqua		Infested siliqua	
	Total seed	% increase Over sole crop	Total seed	% increase Over sole crop
T ₁	23.70 a	39.06 a	23.20 a	45.26 a
T ₂	21.07 b	23.56 b	20.33 c	27.27 c
T ₃	22.80 ab	33.78 ab	21.43 bc	34.25 bc
T ₄	18.60 c	9.26 c	18.07 d	13.22 d
T ₅	23.30 a	36.75 a	22.37 ab	39.95 ab
T ₆	17.03 c	-----	15.97 e	-----
CV%	5.37	22.12	3.82	11.63
LSD _{0.05}	2.06	11.86	1.40	7.01

Values in the column with the same letter(s) are not differ significantly by DMRT (p = 0.05).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

4.8.2 Total seed number per infested siliqua

Table 4.8. shows that significant variation was observed in terms of total seed per infested siliqua at different treatments. The highest number of seed per siliqua (23.20) was recorded in mustard with coriander (T₁) which was closely followed by (22.37) in mustard with wheat (T₅) respectively which were statistically different and significantly greater than all other intercropping treatments. On the other hand the lowest number of seed per siliqua (15.97) was recorded in mustard sole crop (T₆) intercropping treatment.

In case of percent increase of seed per siliqua over sole crop the highest increasing was found (45.26) in mustard with coriander (T₁) intercropping treatment. It was also observed that the

closely statistically similar (39.95) result was found in treatments (T₅) which was combined by mustard with wheat intercropping treatment. On the other hand the lowest increasing of siliqua formation was found (13.22) in mustard with black cumin (T₄) intercropping system.

4.9 Effect of intercropping on seed weight (g) per plant

4.9.1 Total seed weight (g) per healthy plant

Table 4.9 shows that significant variation was observed in terms of total seed weight (g) per healthy plant at different treatments. The highest number of seed weight (g) per plant (9.41) was recorded in mustard with coriander (T₁) followed by (9.14) in mustard with radhuni (T₃) treatment which were statistically different and significantly greater than all other intercropping treatments. On the other hand the lowest number of seed weight (g) per plant (4.91) was recorded in mustard sole crop (T₆). It was also observed that the statistically similar (5.32) result was found in treatments (T₄) which was combined by mustard with black cumin inter cropping system.

Table 4.9 Effect of intercropping on the incidence of mustard aphid in terms of total seed weight per plant and increase over sole crop

Treatments	Healthy plant		Infested plant	
	Total seed weight	% increase over sole crop	Total seed weight	% increase over sole crop
T ₁	9.41 a	91.43 a	8.86 a	89.53 a
T ₂	7.18 c	45.82 b	6.46 cd	38.40 bc
T ₃	9.14 ab	86.07 a	7.98 b	70.53 a
T ₄	5.32 d	8.09 c	5.80 d	24.06 c
T ₅	8.31 b	69.06 a	7.03 c	50.37 b
T ₆	4.91d	-----	4.67 e	-----
CV%	7.67	20.10	6.64	18.52
LSD _{0.05}	1.03	22.74	0.82	19.03

Values in the column with the same letter(s) are not differ significantly by DMRT (p = 0.05).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

In case of percent increase of seed weight (g) per plant over sole crop the highest increasing was found (91.43) in mustard with coriander (T₁) intercropping treatment. It was also observed that the statistically similar (86.07) and (69.06) result was found in treatment (T₃) and treatment (T₅) which was combined by mustard with radhuni and mustard with wheat intercropping plots. On the other hand the lowest increasing of seed weight (g) per plant was found (8.09) in mustard with black cumin (T₄) intercropping system.

4.9.2 Total seed weight (g) per infested plant

Table 4.9 Shows that significant variation was observed in terms of total seed weight (g) per healthy plant at different treatments. The highest number of seed weight (g) per plant (8.86) was recorded in mustard with coriander (T₁) treatment which was statistically different and significantly greater than all other intercropping treatments. Second highest result was recorded (7.98) in treatment (T₃) which was combined by mustard with radhuni intercropping plot. On the other hand the lowest number of seed weight (g) per plant (4.67) was recorded in mustard sole crop (T₆).

In case of percent increase of seed weight (g) per plant over sole crop the highest increasing was found (89.53) in mustard with coriander (T₁) intercropping treatment. It was also observed that the statistically similar (70.53) result was found in treatment (T₃) which was combined by mustard with radhuni intercropping plot. On the other hand the lowest increasing of siliqua formation was found (24.06) in mustard with black cumin (T₄) which was closely followed by (38.40) in mustard with fenugreek intercropping plot.

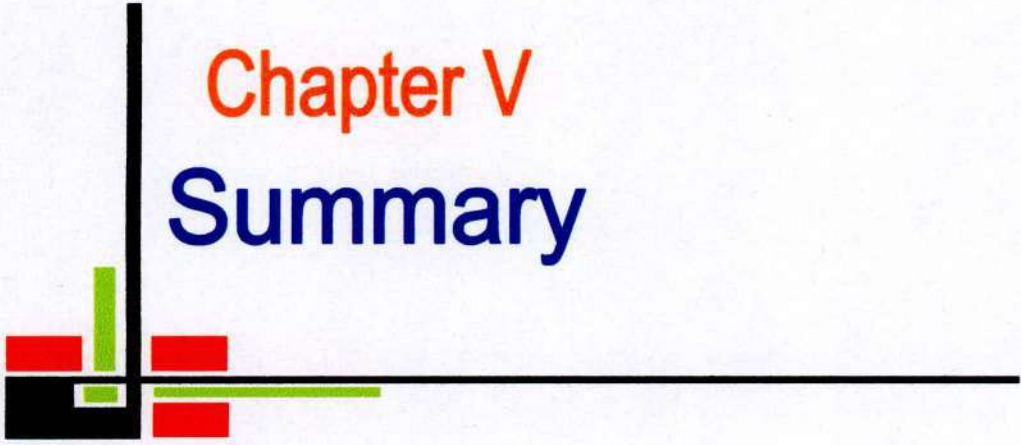
Table 4.10 Effect of intercropping on the seed yield of mustard

Treatments	Total seed wt./ plot (g)	Yield/plot (ton/ha)
T ₁	297.2 a	0.49 a
T ₂	186.2 bc	0.31 bc
T ₃	235.7 b	0.39 b
T ₄	158.0 cd	0.26 cd
T ₅	215.8 b	0.35 bc
T ₆	116.8 d	0.19 d
CV%	14.99	15.41
LSD_{0.05}	54.99	0.10

Values in the column with the same letter(s) are not differ significantly by DMRT ($p = 0.05$).

T₁ = mustard + coriander, T₂ = mustard + fenugreek, T₃ = mustard + radhuni, T₄ = mustard + black cumin, T₅ = mustard + wheat, T₆ = mustard (control).

Table 4.10 shows that the total highest seed weight (g) per plot (297.2) as well as total highest yield per plot (ton/ha) was recorded (0.49 t/ha) in mustard with coriander (T₁) which was statistically different and significantly greater than all other intercropping treatments. Second highest result was recorded (235.7) as well as (0.39 t/ha) from mustard with radhuni (T₃) followed by (215.8) as well as (0.35 t/ha) from mustard with wheat (T₅) and which were closely followed by (186.2) as well as (0.31 t/ha) from mustard with fenugreek (T₂) intercropping treatments. On the other hand the lowest seed weight (g) per plot (116.8) as well as (0.19 t/ha) was recorded in mustard sole crop (T₆).



Chapter V
Summary

CHAPTER V

SUMMARY



A field experiment was carried out at the farm of Sher-e-Bangla Agricultural University, to investigate the effect of intercropping on the incidence of aphid for mustard production during the period from November 2013 to March 2014. The crops used for intercropping were coriander, fenugreek, radhuni, black cumin and wheat. The control treatment was tested only with mustard for comparing with other intercropping system.

The lowest aphid infestation was found (7.77, 15.34, 30.35 and 17.82%) in mustard with coriander (T_1) crop combination and the highest was found (16.22, 35.67, 50.00 and 33.96%) in the mustard control (T_6) intercropping system in the early, mid, late stage respectively. It was also observed that the highest percentage of leaf infestation per plant (2.35, 7.62, 12.43 and 7.47) was recorded in the control whereas the lowest percentage of leaf infestation per plant (0.58, 1.99, 5.95 & 2.84) was recorded in mustard with coriander (T_1) intercropped combinations in the early, mid, late stage and in mean respectively. At same stages the highest percentage of flower bud infestation per plant (23.14, 43.21, 53.13 and 39.16) caused by aphid in the control (T_6) and the lowest was found in (13.84, 20.81, 36.64 and 23.76) in mustard with coriander (T_1). On the other hand, the highest percentage of flower infestation per plant (25.81, 29.49, 43.06 and 32.78) was recorded in the control (T_6) while the lowest (10.43, 14.93, 27.78 and 17.72) was in mustard with coriander (T_1) intercropped combinations. In case of healthy plant, the highest number of branch per plant (5.35) was recorded in sole mustard (T_6) and lowest number (4.26) was recorded in mustard with wheat (T_5) intercropping system.

In case of infested plant, the highest number of branch per plant (5.46) was estimated in the control (T_6) and the lowest number (4.39) was recorded in mustard with coriander (T_1) intercropping system. In the healthy branches the highest number of siliqua per branch (25.18, 27.57 and 26.38) was recorded in mustard with coriander (T_1) and the lowest number

of siliqua per branch (21.59, 22.67 and 22.13) was recorded in the control (T₆) in early, late and average respectively. On the contrary in infested branches the highest number of siliqua per branch (24.93, 26.53 and 25.73) was estimated in mustard with coriander (T₁) and the lowest number of siliqua per branch (16.47, 19.20 and 17.83) was recorded in control (T₆). At the same stages the highest number of total siliqua per infested plant (118.00) was recorded in mustard with Coriander (T₁) and the lowest number of total siliqua per infested plant (95.17) was observed in the control (T₆). Again in percent siliqua infestation, the highest percentage of siliqua infestation (98.08) caused by aphid in the control (T₆) and the lowest percentage of siliqua infestation (65.13) was recorded in mustard with coriander (T₁).

In case of total number of seed per healthy siliqua highest seed number was recorded (23.70) in mustard with coriander and the lowest number was (17.03) in the control. Again in case of total number of seed per infested siliqua, the highest seed number was recorded (23.20) in mustard with coriander and lowest number was (15.97) in the control. In case of seed weight per healthy plant results showed that the highest weight was (9.41g) in mustard with coriander (T₁) and lowest weight was recorded (4.91) in the control. Again in case of total seed weight per infested plant, the highest weight (8.86g) recorded in mustard with coriander (T₁) and the lowest weight (4.67) in the control. The significant difference was found in case of total seed weight per plot and the highest seed weight per plot was recorded (297.2g) in mustard with coriander (T₁) intercropping plots. On the other hand lowest seed weight per plot was recorded (116.8g) in control (T₆).

The date wise trends of aphid infestation showed always higher in the control as compare to intercropped plots in case of infested leaves per plant aphid infestation was always higher in the control (T₆) and secondly mustard with wheat (T₅). In case of infested flower buds per plant and infested flowers per plant highest infestation had occurred in mustard with black cumin (T₄) and mustard with fenugreek. But on the other hand in every case such as infested plants per plot, infested leaves per plant, infested flower buds per plant and infested flower per plant lowest infestation was recorded in mustard with coriander (T₁) intercropping plots.




Chapter VI

Conclusion and Recommendations

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

From the study, it may be concluded that incidence of mustard aphid infestation was less in spices intercropping system. When aphid infestation was higher in intercropping system then it was observed that siliqua formation was lower and seed yield also lower. At that time, when aphid infestation was lower in spices intercropping system then, siliqua formation and seed yield were higher. The overall study revealed that intercropping may be considered as an eco friendly pest management practice for mustard production by which it could reduce the pest infestation without use of any chemical insecticide. From the overall study among the intercropping system, sole mustard showed most infested condition and mustard intercropped with coriander intercropping system showed less infestation comparing other intercropping treatments. However, further study is recommended to assess the environment friendly management practices of mustard aphid by various spices intercropping systems prevailing in different agro ecosystems of Bangladesh.



Chapter VII
References

CHAPTER VII

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