EFFECT OF SOWING TIME AND LENTIL VARIETIES ON INCIDENCE OF INSECT PESTS AND THEIR PREDATORS

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CERTIFICATE

This is to certify that thesis entitled **"Effect of Sowing Time and Lentil Varieties on Incidence of Insect Pests and Their Predators"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY,** embodies the result of a piece of *bona fide* research work carried out by **Mst. Shahana Islam**, **Registration No. 08-03171** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Place: Dhaka, Bangladesh

(Dr. Md. Abdul Latif)
Associate Professor
Supervisor

DEDICATED
TO
MY BELOVED PARENTS

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EFFECT OF SOWING TIME AND LENTIL VARIETIES ON INCIDENCE OF INSECT PESTS AND THEIR PREDATORS

BY

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ABSTRACT

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, and Dhaka, Bangladesh to evaluate the effect of sowing time and lentil (Lens culinaris) varieties on incidence of insect pests and their predators during the period from October 2008 to April 2009. The experiment comprised two factors, viz., Factor A: Sowing time (4 levels) - S_1: Sowing on 06 November, S_2: Sowing on 16 November, S_3: Sowing on 26 November and S_4: Sowing on 06 December; Factor B: Variety (4 levels) - V_1: BARI Masur-3, V_2: BARI Masur-4, V_3: BARI Masur-5 and V_4: BARI Masur-6. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Incidence of insect pests was recorded for the entire cropping season. Aphid, whitefly, jassid, pod borer were found as insect pests and spider, lady bird beetle were predators of these pests. In consideration of sowing time, the lowest number of aphid, whitefly, jassid, pod borer, spider and lady bird beetle (4.07, 1.89, 2.55, 1.88, 2.00 and 2.69, respectively) was recorded from S_3 while the highest number (5.48, 2.28, 3.30, 2.42, 2.57 and 4.46) was found from S_1. On the other hand, the minimum number of aphid, whitefly, jassid, and pod borer, spider and lady bird beetle (4.56, 2.03, 2.83, 2.07, 2.36 and 3.97) was recorded from the variety V_4 while the highest number of insect pests (5.74, 2.37, 3.43, 2.54, 2.31 and 4.41) was found variety from $V_{1.}$ Combined, the highest number of aphid, whitefly, jassid, pod borer, spider and lady bird beetle (6.93, 2.70, 4.03, 2.07, 3.00, 2.87, 5.53) from S_1v_1 treatment combination and the lowest number (3.67,1.80,2.27,1.67,1.47, 2.10) from S_3V_3. At early, mid and late fruiting stage, for different sowing time, variety and their combined effect showed a statistically significant variation in number of healthy pods, infested pods per plant and percentage of infestation.

Chapter I
Introduction

INTRODUCTION

Lentil, mungbean, grasspea, blackgram, chickpea, fieldpea, cowpea are the common pulse crops in Bangladesh. Pulses are important crops because it provides a cheap source of easily digestible dietary protein for the human being. It supplies about four times as much protein and eight times as riboflavin and the caloric value of it is equal to rice (Anonymous, 1966). Moreover, it is known as poor man's meat. It is a versatile source of nutrients for man, animal and soil (Miah, 1976). According to FAO (1999) a minimum requirement of pulse is 80 g per head per day whereas; it is only 14.19 g in Bangladesh context (BBS, 2008).

Lentil (*Lens culinaris* Medik.) is one of the major pulse crops in Bangladesh, which ranks third among the lentil growing countries of Asia pacific region (FAO, 2004). It is the second most important pulse crop in area and production, but stands first in the consumer's preference in this country. During 2006-2007, it was grown on about 134,642 ha of land producing 115,370 tones of grain, with an average yield of 857 kg ha^{-1} and contributes about 33% to the total pulses production (BBS, 2008). Domestic pulse production satisfies less than half of the country's demands. The rest, near about 140,000 tones, need to import at a cost of about US$ 32.2 million per annum. Considering yield and nutritive value, lentil is better than the traditional legume and other cereals. Moreover this crop fits well in the cropping pattern of Bangladesh. Lentil cultivation is mostly concentrated in the Gangetic Flood Plain of western part of Bangladesh.

In spite of so many advantages, lentil is generally grown under minimum fertility and following minimum or without management practices in the country. The development of high potential genotypes with good, stable yield and higher protein content is important to improve yield status of the crop. The existing varieties in Bangladesh are mostly low yielding. The average yield of lentil in Bangladesh is gradually declining. Several factors are responsible for low yield of lentil, such as, less attention on cultural practices, lack of pest control measures, post-harvest losses, the use of traditional varieties or landraces with low genetic potential and instability of yield. The productivity of this crop is very poor in Bangladesh compared to that in the other countries of the world.

In Bangladesh, pulses are attacked by eleven species of insect pests (Rahman *et al*.,2006). Among these pests aphid (*Aphis craccivora* K), whitefly (*Bemesia tabaci* G), jassid (*Eurymela fenestrate*) and the pod borer, (*Helicoverpa armigera* Hubner) are the most serious insect pests of the growing areas of the country (Begum *et al*.,1992). The young nymphs of these pests feed on the foliage for some time and later suck the immature pod. In later stage, the young larvae also bore in to the pod. In a country wide survey, averages of 30 to 40 percent pods were found to be damaged for that and it was estimated as 400 kg/ha yields losses (Sachan and Katti, 1994). In favorable condition, the pod damage may go to 90-95% (Shongal and Ujagir, 1990).

The development of high yielding and high protein containing legume with other desirable characters is needed to improve the yield status of this crop.

More work is needed for making a tangible improvement of this crop. A number of agronomic practices have been found to influence the yield of vegetable crops (Boztok, 1985). Sowing time had a marked effect on growth and development of crops (Mittel and Srivastava, 1964). Optimum sowing time provides more time for the growth and development of plant which is favorable for higher yield whereas both early and late sowing hinder the growth and development with lowest yield potential.

Lack of quality seeds of high yielding varieties and optimum time of sowing are also two major limiting factors that influences insects infestation and ultimately hindering the productivity of lentil. Therefore, experimental evidences indicate that there are enough scopes to increase the productivity of lentil using appropriate variety and optimum sowing time. In this study, an attempt was made to evaluate the yield level of lentil variety under different sowing times with a view of exploring and exploiting the potential productivity of lentil. Considering the present situation, it is necessary to adjustment of sowing time and suitable variety for the management of insect pests and for attaining the highest yield of lentil. Therefore, the present study was planned and designed with the following objectives:

- To find out the proper time of sowing of lentil in relation to insect pests attack and the abundance of their predator
- To identify the tolerant varieties of lentil and
- To know the combined effect of sowing time and different varieties in managing the infestation of insect pests in lentil.

Chapter II

Review of Literature

REVIEW OF LITERATURE

Lentil (*Lens culinaris* Medik.) is one of the most important pulse crops in Bangladesh and the crop has conventional less concentration by the researchers on various aspects because normally it grows without less care or management practices. For that a very few studies regarding growth, development, insect pest management and yield of lentil have been carried out in our country as well as many other countries of the world. Aphid, whitefly, jassid, pod borer, spider, lady bird beetle are commonly found in the field of lentil. Among them the pod borer, *Helicoverpa armigera* (Hubner) is a main and serious pest of lentil in Bangladesh and elsewhere in the world. For better understanding efforts have been made to review the available literature related to this pest distribution, pest status and host range, and its biology is necessary. However, some of the important and informative works regarding the variety and sowing time so far been done at home and abroad on this crop and their findings regarding the growth and yield of this crop have been reviewed in this chapter under the following headings-

2.1 Sucking pests of lentil

2.1.1 Distribution of sucking pests

The origin of pea aphid is likely Europe or Asia, though it is now found throughout the world in regions with temperate climates. In North America, it was first noted about 1878, and became first serious pest problem about 1900 when it caused extensive damage in the mid-Atlantic states from New Jersey to

Virginia, and in eastern Canada from Nova Scotia to Quebec. By the 1950s, it had spread throughout the United States and Canada.

Blue alfalfa aphid is native to Asia, but it has spread to Australia, New Zealand, and South America in addition to North America. First observed in California in 1974, it now is widely distributed blue alfalfa aphid reached Nebraska in 1979, Kentucky and Georgia in 1983, and Maryland in 1992. This species is not yet known as a pest in Canada (Srivastava and Auclair, 1999）.

2.1.2 Pest status and host range of sucking pest

Aphid and alfalfa aphid are known principally as pests of Leguminosae. As they are efficient vectors of plant viruses, however, they also cause loss in crops on which they normally do not feed, such as cucurbits.

Pea aphid is prone to develop races or subspecies with slightly different host ranges, so populations may differ somewhat in their damage potential to specific legume. Pea is the most suitable vegetable host for this species, and faba bean and lentil are sometimes damaged. Other hosts that are important in pea aphid biology are alfalfa, sweet pea, vetch, and such clovers as alsike clover, red clover, white clover, and sweet clover. Blue alfalfa aphid is not widely recognized as a vegetable pest. Ellsbury and Nielson (1981) demonstrated that pea, lentil, and cowpea were suitable hosts. For the pea aphid, many legume forage crops are suitable hosts.

Acyrthosiphon aphids complete their life cycle quickly. These aphids can reach maturity and begin reproduction 10-12 days after birth. The number of generations completed annually by pea aphid is estimated at about 13 in India, 14-15 in Wisconsin, 15 or more in Washington and Oregon, and 20-22 in Virginia. The overwintering stage of aphid varies with climate; in cold regions the eggs overwinter, in warm areas females persist, and in temperate climates both eggs and females can be found during winter months. In blue alfalfa aphid, overwintering is similar. Unlike many species of aphids, these species do not migrate to a woody host for overwintering. However, they do commonly disperse from annual legumes in the summer to perennial legumes such as alfalfa and clover in the autumn, so the difference in behavior is not great (Ellsbury and Nielson, 1981).

2.2 Pod borer of lentil

2.2.1 Distribution of pod borer

Pod borer is a polyphagous pest, which spreads in wide geographical areas and it extends from Cape Verde Islands in the Atlantic, through Africa, Asia and Autralasia, to the South Pacific Islands and from Germany in the north to New Zealand in the south (Hardwick, 1965). Rao (1974) stated that in India, *H. armigera* is distributed over a wide range and caused serious losses to many crops, including chickpea, particularly in the semi-arid tropics. Ibrahim (1980) observed that *Heliothis* spp. is of considerable economic importance as pests on many Egyptian crops but *H. armigera* is the most abundant species throughout Egypt. Zalucki *et al.* (1986) reported that *H. armigera* was one of the widest distributions of any agricultural pests, occurring throughout

Asia, Australia, New Zealand, Africa, southern Europe and many Pacific islands.

2.2.2 Pest status and host range of pod borer

Jayaraj (1962) reported that *Heliothis* could breed on a wide range of plants. The crops attacked in many countries were maize, sorghum, oats, barley, pearl millet, chickpea, pigeonpea, cowpea, peas, various beans, cotton, sunflower, safflower, tobacco, tomato, brinjal, cucurbits, sweet potato, groundnut, flax, citrus, sunhemp, potato etc. Bhatnagar and Davies (1978) reported that about 50 species of crop plants and 48 species of wild and weed species of plants for *H. armigera* at Patancheru, Andhra Pradesh, India, whereas 96 crops and 61 weeds and wild species have been recorded elsewhere in India. The most important carryover weed hosts in the hot summer season are *Datura metel, Acanthospernium hispidum* and *Gynandropsis gynandra* for *H. armigera, H. assulta* and *H. pelligera.*

Reed and Pawar (1981) observed that *H. armigera* was the dominant and primary pest of cotton, maize and tomatoes in some countries of Africa, Europe, America, Australia and Asia. In India, it was a dominant pest on cotton in some areas and in most of the areas, on several other crops particularly pigeonpea and chickpea. On both the major pulse crops, *H. armigera* commonly destroyed more than 50 of the yield. Garg (1987) studied the host range of *H. armigera* in the Kumaon Hills, India and found that larvae of *H. armigera* infested different plant parts of variety of crops like wheat, barley, maize, chickpea, pea, tomato, pigeon pea, lentil, onion and okra. He also pointed that chickpea appeared to be the most susceptible crop followed by pigeonpea, tomato and pea. In addition to these cultivated plants, it was also observed on some wild grasses and ornamental plants such as roses and chrysanthemums.

Fitt (1991) cited from a study in the south Asian region that *Helicoverpa* was a serious pest of cotton, chickpea, pigeonpea, groundnut, cowpea, *Vigna* species, okra, tomato, castor, sunflower, maize, sorghum and many other crops.

2.3 Biology of pod borer

2.3.1 Host preference for oviposition

Parsons *et al.* (1937) reported that chickpea was the most attractive for oviposition of pod borer. While, Reddy (1973) and Loganathan (1981) reported that pigeonpea was the preferred host for oviposition.

Vijayakumar and Jayaraj (1981) studied the preferred host plants for oviposition by *H. armigera* and found in descending order, pigeonpea > fieldpea > chickpea> tomato> cotton> chillies> mungbean> sorghum.

2.3.2 Mating and oviposition

The eggs were laid singly, late in the evening, mostly after 21.00 hr to midnight. On many host plants, the eggs were laid on the lower surface of the leaves, along the midrib. Eggs were also laid on buds, flowers and in between the calyx and fruit. Roome (1975) studied the mating activity of *H. armigera* and reported that from 02.00 to 04.00 hr the males flew above the crop while the females were stationary and released a pheromone. During this period males were highly active and assembled around females.

Singh and Singh (1975) found that the pre-oviposition period ranged from 1 to 4 days, oviposition period 2 to 5 days and post-oviposition period 1 to 2 days. Eggs were laid late in the evening, generally after 21.00 hours and continued up to midnight. However, maximum numbers of egg were laid between 21.00 and 23.00 hours. The moths did not oviposit during the daytime. Loganathan (1981) observed peak mating activity at 04.00 hr.

Tayaraj (1982) reported that oviposition usually started in early June, with the on set of pre-monsoon showers, adults possibly emerging from diapausing pupae and also from larvae that had been carried over in low numbers on crops and weeds during the summer. Reproductive moths were recorded through out the year ovipositing on the host crops and weeds with flowers. The pest multiplied on weeds, early-sown corn, sorghum, mungbean and groundnut before infesting pigeonpea in October-November and chickpea in November-March.

Zalucki *et al.* (1986) reported that females laid eggs singly or in groups of 2 or 3, on flowers, fruiting bodies, growing tips and leaves. During their two weeks life span, females laid approximately 1400 eggs. Also cited that the pre-oviposition period ranged from 2 to 4 days, oviposition period 6 to 9 days and post-oviposition period 0 to 2 days. Moth oviposited 715 to 1230 eggs with an average of 990.70 ± 127.40. The fecundity varied from 510 to 1676 and the average being 1142 ± 360.6 eggs.

2.3.3 Egg

The eggs of *H. armigera* are nearly spherical, with a flattened base, giving a somewhat dome-shaped appearance, the apical area surrounding the micropyles smooth, the rest of the surface sculptured in the form of longitudinal ribs, The freshly laid eggs are 0.4 to 0.55 mm in diameter, yellow-white, glistening, changing to dark brown before hatching .The incubation period of the eggs is longer in cold weather and shorter in hot weather, being 2 to 8 days in South Africa and 2.5 to 17 days in the United States (Pearson and Darling, 1958), and 2 to 5 days in India (Srivastava and Saxena, 1958; Singh and Singh, 1975).

2.3.4 Larva

The newly hatched larva is translucent and yellowish white in color, with faint yellowish orange longitudinal lines. The head is reddish brown, thoracic and anal shields and legs Brown and the setae dark brown. The full-grown larva is about 35 to 42 mm long; general body color is pale green, with one broken stripe along each side of the body and one line on the dorsal side. Short white hairs are scattered all over the body. Prothorax is slightly more brownish than meso and metathorax. Crochets are arranged in biordinal symmetry on the prolegs. The underside of the larva is uniformly pale. The general color is extremely variable; and the pattern may be in shades of green, straw yellow and pinkish to reddish brown or even black (Neunzig, 1964; Singh and Singh, 1975).

Temperature affects the development of the larva considerably. The larval duration varied from 21 to 40 days in California, 18 to 51 days in Ohio (Wilcox *et al*., 1956), and 8 to 12 days in the Punjab, India (Singh and Singh, 1975) on the same host, tomato. The larval stage lasted for 21 to 28 days on chickpea (Srivastava and Saxena, 1958); 2 to 8 days on maize silk; 33.6 days on sunflower corolla (Coaker, 1959)

There are normally six larval instars in *H. armigera* but exceptionally, during the cold season, when larval development is prolonged, seven instars regularly found in Southern Rhodesia (Pearson and Darling, 1958).

2.3.5 Pupa

The pupa is 14 to 18 mm long, mahogany-brown, smooth-surfaced and rounded both interiorly and posteriorly, with two tapering parallel spines at the posterior tip (Singh and Singh, 1975). The pupa of *H. armigera* undergoes a facultative diapause. The non-diapause pupal period for *H. armigera* was recorded as 14 to 40 days in the Sudan Gezira, 14 to 57 days in Southern Rhodesia, and 14 to 37 days in Uganda and 5 to 8 days in India (Jayaraj, 1982). The pupal period ranged from 14 to 20 days in Gujarat, India.

2.3.6 Adult

The female *H. armigera* is a stout-bodied moth, 18 to 19 mm long, with a wingspan of 40 mm. The male is smaller, wing span being 35 mm. Forewings are pale brown with marginal series of dots; black kidney shaped mark present on the underside of the forewing; hind wings lighter in color with dark colored patch at the apical end. Tufts of hairs are present on the tip of the abdomen in females (ICRISAT, 1982). The female lived long. The length of life is greatly affected by the availability of food, in the form of nectar or its equivalent; in its absence, the female fat body is rapidly exhausted and the moth dies when only 3 to 6 days old (Jayaraj, 1982).

The longevity of laboratory reared males and females were 3.13 ± 0.78 and 6.63 ± 0.85 days, respectively (Singh and Singh, 1975). Adult period in male ranged from 8 to 11 days with an average of 9.15 ± 0.90 days and in females 10 to 13 days with an average of 11.40 ± 0.91 days.

2.3.7 Generations

Hsu *et al*. (1960) observed three generations of *H. armigera* each year in China. While, Reed (1965) reported that the pest completed four generations from September to March under western Tanganyika conditions. Singh and Singh (1975) reported that *H. armigera* passed through four generations in the Punjab, India; one on chickpea during March; two on tomato, from the end of March to May; and one on maize and tomato in July-August.Seven to eight generations of *H. armigera* were present each year in Andhra Pradesh, India.

2.4 Pest Incidence

Southwood and Way (1970) cited that the type and abundance of biodiversity in agriculture will differ across agro ecosystems which 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 permanence 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.

Saxena (1972) stated that a proper combination of crops is important for the success of inter cropping systems, when two are to be grown together. It is imperative that the peak period of growth of the two crop species should not coincide. 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.

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, 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, 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.

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 (Baliddawa, 1985).

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. 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 bio-diversification 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 yields, energy conservation and less dependence on external inputs.

Relative population density of sucking pests on different cultivars of lentil and okra was studied Mingora, Swat by Shakeel *et al.,* (1996). Population density of aphid (*Aphis gossypii* Glov.) per leaf ranged 0.4-4.3, 1.2-4.8, 2.6-4.6, 0.1-5.9 and 0.0-4.8 on climson spineless, T-13, Pusa Green, Perking Dwarf, Rich Green, and Swat local cultivars of okra with a seasonal average numbers of 2.8, 3.1, 2.8, 3.4, 2.9, and 2.8, respectively. None of the cultivars indicated resistance to aphids. The aphids were more abundant during the initial period of plant growth. Population density of the Jassid *Amrasca biguttula biguttula* (Shir.) ranged 0.9-79.4, 1.5- 78.7, 2.2-85.2, 1.2-60.8, 2.1-92.2, and 1.4-60.9, with seasonal average of 32.2, 32.4, 34.9, 26.3, 36.5, and 25.2, respectively, on the above mentioned cultivars**.**

The relative abundance of lentil aphid was investigated at different sowing dates (21 November, 28 November, 5 December and 12 December) during rabi seasons in Ishurdi, Bangladesh by Hossain *et al*., (2006). Lentil aphid appeared in the field in the first week of January. The crop sown in November received less aphid infestation and consequently produced higher yield than the crop sown in December and found that to protection measures taken against aphids and this was also dependent on the different dates of sowing.

Sowing dates significantly affected aphid infestation in mungbean. Percentage of plant infestation by aphid in different dates of sowing ranged from 8.57% to 57.37%. The highest percentage (57.37%) of plant infestation was observed in February 21 sowing crops followed by February 14 and February 28. Aphid infestation was lower in those crops sown in March than those of February sowings. The lowest percentage (8.57%) of plant infestation was observed in April 03 sowing crop which was statistically identical to March 20, April 10, April 17, April 24 and May 01. Generally, it is seen that aphid infestation was higher in February sowings crops followed by March, April and May sowings. This might be due to lower temperature in early sowings crops which favoured population increase to higher infestation. Hossain *et al*. (2000) reported that aphid infestation in lentil varied significantly depending on sowing time.

Current recommendations for sowing of lentils in the southern Mallee of Victoria, Australia, to attain maximum yield is to sow in mid-late May at a targeted plant density of 120 plants/m^2. However, with the introduction of new cultivars with different agronomic characteristics, sowing dates and plant densities may need to be altered to achieve maximum yield. During 2000, field experiments were conducted by Brand *et al*. (2003) at Warne and Rosebery, Australia, to study the effects of sowing date (early May, late May, mid June, early July) and in 2001, the effects of sowing date (early May, mid June, mid July) and plant density (60, 90, 120, 150 and 250 plants/m^2) on the growth and grain yield of lentil cultivars (Nugget, Northfield, Cassab and Digger). The optimum sowing dates for all cultivars in 2000 were mid June to early July and in 2001 mid May to mid June.

An experiment was conducted at Pulses Research Center, Ishurdi, Pabna, Bangladesh during kharif-I to find out the insect pests attacking mungbean crop sowing at different dates to determine the optimum date(s) of sowing. It is seen that the incidence and population fluctuation of various insect pests was very much dependent on the prevailed climatic conditions of the cropping season. The early (February 14 to March 06) and late sown (mid April to onward) crops received higher pest infestation than mid sown (March 13 to April 10) crops. The highest yield (1548 kg/ha) was obtained from March 27 sowing crop. The second highest yield (1279 kg/ha) was obtained from March 13 sowing which was statistically identical to March 20, April 03 and April 10 sowings crop. Again, the delayed sowings after mid April to onward provide yield of 717 kg/ha to 178 kg/ha which were very poor. Hence, for ensuring higher yield and less insect pest's infestation, mungbean should be sown within the period of March 13 to April 10 and the best date of sowing should be March 27 by Hossain *et al.* (2000).

Relative abundance of lentil aphid, *Aphis craccivora* Koch were investigated and yield loss assessment at different sowing dates during rabi season of 1999-2000 and 2000-2001 at Ishurdi Bangladesh. Lentil aphid appeared in field in the first week of January. The maximum aphid population (15.82/twig) was recorded in the first week of February 2000-2001, but the population reached to the peak was in the last week of January in 1999-2000, subsequently rainfall caused a sudden reduction of aphid population in latter dates. Aphid population and infestation increased with the delayed dates of sowing. The crop sown in November received less aphid infestation and consequently produced higher yield than the crop sown in December. During 1999-2000, the avoidable yield loss due to aphid infestation was recorded 0.90 to 6.78% and in 2000-2001 it was 2.65 to 9.00% depending on the different dates of sowing. Avoidable yield loss was less in November sowing crop than the crop sown in December. On the other hand, yield increased by 0.91 to 7.27% and 2.72 to 9.89% in 1999-

2000 and 2000-2001 respectively, due to protection measures taken against aphids and this was also depend on different dates of sowing (Hossain *at el*.,2006).

Pod damaged by pod borer varied significantly due to different sowing dates. The lowest pod damage (9.25%) was observed in March 27 sowing crops which was statistically identical to February 14, February 21 and March 13 sowing crop. The highest pod damage (38.54%) was observed in May 01 sowing crops which was statistically identical to April 17 and April 24 sowing crops. It is seen that in February and March sowing crop pod borer damage was comparatively low than that of April and May sowing crops. This might be due to higher rainfall in April-May sowings favouring pod borer population increase caused higher pod infestation. Jayaramiah and Babu (1990) reported rainfall as the influencing factor of pod borer moth emergence as well as higher pod borer infestation.

Suhil *et al*. (1999) stated that predatory potential of *Coccinella septempunctata* L. on cotton aphids (*Aphis gossypii* Glov.) was studied under laboratory conditions at 21 ±1 degree centigrade and 70 ± 5 percent relative humidity. Both adult and larva of predator voraciously consumed on an average, 60, 56 and 141.01 aphids per day, respectively and the total developmental period was noted to be 18.75 days.

Chapter III

Materials and Method

MATERIALS AND METHODS

The experiment was conducted to know the effect of sowing time and different varieties on incidence of insect pests of lentil during the period from October 2008 to April 2009. The details materials and methods of this experiment are presented below:

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, which is situated in $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude (Anon, 1989).

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) corresponding AEZ No. 28 and is shallow red brown terrace soil. The land of the selected experimental plot is medium high under the Tejgaon series (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Dhaka and has been presented in Appendix I.

3.3 Climate

The climate of experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experimental period was collected from Bangladesh

Meteorological Department (Climate Division), Sher-e-Bangla Nagar and has been presented in Appendix II.

3.4 Planting material

Four lentil variety viz., BARI Masur-3, BARI Masur-4, BARI Masur-5 and BARI Masur-6 were used as the test crop as well as a factor of this experiment. The seeds were collected from the Pulse Seed Division, Bangladesh Agricultural Research Institute, Joydebpur, and Gazipur. Details of these varieties are presented below as per BARI publication:

3.4.1 BARI Masur-3

BARI Masur-3 is a recommended cross variety of lentil. It grows in rabi season and was released 1985. It is resistant to diseases, insects and other pests especially to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 1.9-2.0 t ha^{-1}. Seeds contain 25.50% protein and 59.60% carbohydrate (Anon, 1999).

3.4.2 BARI Masur-4

BARI Masur-4 is a recommended variety of lentil. It grows in rabi season and was released in 1996. This variety is resistant to diseases, insects and pests especially to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 1.9-2.0 t ha^{-1}. Seeds contain 25.80% protein and 59.80% carbohydrate (Anon, 1999).

3.4.3 BARI Masur-5

BARI Masur-5 is a recommended cross variety of lentil. It grows in rabi season and was released in 2006. It is resistant to diseases, insects and other pests. This variety is also resistant to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 2.1-2.2 t ha^{-1}. Seeds contain 26.93% protein and 59.90% carbohydrate (Anon, 2008).

3.4.4 BARI Masur-6

BARI Masur-6 is a recommended cross variety of lentil. It grows in rabi season and was released in 2006. The variety is resistant to diseases, insects and other pests. It is also resistant to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 2.2-2.3 t ha^{-1}. Seeds contain 27.12% protein and 59.40% carbohydrate (Anon, 2008).

3.5 Land preparation

The soil was first opened with the tractor drawn disc plough. Then the soil was ploughed and cross ploughed. Ploughed soil was then brought into desirable fine tilth by the operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 20 October and 30 October 2008, respectively. Experimental field was divided into unit plots following the design of experiment. The plots were spaded one day before seed sowing and the basal dose of fertilizers was incorporated thoroughly with the soil.

3.6 Fertilizer application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, Urea, TSP and MP was applied as basal dose at the time of land preparation.

Table 1. Dose of application of fertilizers in lentil field (Anon, 1999)

Fertilizers and Manures	Dose/ha
Cowdung	10 tons
Urea	45 kg
TSP	85 kg
MP	35 kg

3.7 Treatments of the experiment

The experiment consists of two factors:

Factor A: Sowing time (4 levels)

S_1: Sowing on 06 November

S_2: Sowing on 16 November

S_3: Sowing on 26 November

S_4: Sowing on 06 December

Factor B: Variety (4 levels)

V_1: BARI Masur-3

V_2: BARI Masur-4

V_3: BARI Masur-5

V_4: BARI Masur-6

There were 16 treatment combinations for the experiment; they were S_1V_1, S_1V_2, S_1V_3, S_1V_4, S_2V_1, S_2V_2, S_2V_3, S_2V_4, S_3V_1, S_3V_2, S_3V_3, S_3V_4, S_4V_1, S_4V_2, S_4V_3, and S_4V_4.

3.8 Experimental design and lay out

The two factorial experiments were laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 44.50 m × 11.50 m was divided into three equal blocks. Each block was divided into 16 plots, where 16 treatment combinations were allocated at random. There were 48 unit plots altogether in the experiment. The size of the each unit plot was 3.0 m × 2.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

3.9 Seed sowing

The lentil seeds were sown as per the sowing date of treatment i.e., November 06, 16, 26, and December 06 in 2008. Seeds were treated with Bavistin before sowing the seeds to control the seed borne diseases. The seeds were sown in rows in the furrows having a depth of 2-3 cm. Line to line distance was 30 cm and plant to plant distance was 8-10 cm.

3.10 Intercultural operations

3.10.1 Thinning

Seeds were germinated four days after sowing (DAS). Thinning was done two times; first thinning was done at 8 days after sowing and second was done at 15 days after sowing maintain 10 cm between plants to obtain proper plant population in each plot.

3.10.2 Irrigation and weeding

Irrigation was done at 20 and 30 DAS. The crop field was weeded twice; first weeding was done at 15 DAS and second at 30 DAS.

3.11 Monitoring and data collection

The lentil plants of different sowing time and variety were closely examined at regular intervals commencing from germination to harvest. The following data were collected during the course of the experiment.

- Incidence of insect pests and their predators
- Number of healthy fruits
- Number of infested fruit
- Fruit infestation in number (%)

3.12 Incidence of insects

Incidence of sucking pest per plant was recorded at fifteen days interval from randomly tagged 5 plants in each row and such that 25 plants were selected in each plot. Population was counted by visual observation method at early in the morning.

3.13 Number of healthy pods

Number of healthy pods per plant was recorded at fifteen days interval from randomly tagged 5 plants in each row and such that 25 plants were counted in each plot. Then number of healthy and infested pods was counted from each of the selected plants. Average number of infested and healthy pods were calculated from these date.

3.14 Determination of pod borer infestation per plant

Pod borer infestation per plant was recorded at fifteen days intervals from the randomly tagged 25 plants per plot and starting from flowering to pod maturity.

The entire period were divided into early, mid and late fruiting stage and percentage of pod damage due to pod borer was also calculated from the pods of 5 randomly selected plants from each rows in number.

3.15 Determination of pod borer damage in number

All the pods were counted from 5 randomly selected plants from each rows and 25 plants from each plot and examined. The damaged (bored) and total numbers of pods were counted and the percent pod damage was calculated using the following formula:

$$\% \text{ Pod damage} = \frac{\text{Number of damaged pod}}{\text{Total number of pod}} \times 100$$

3.16 Statistical analyses

The data on incidence of insect pests of lentil were statistically analyzed to find out the differences due to different sowing time and variety and their interactions. The mean values of all the characters were calculated and analyses of variance were performed by the ‘F’ (variance ratio) test. The differences among the mean values of different parameters were estimated by the Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

RESULTS AND DISCUSSION

The study was conducted to evaluate the effect of sowing time and different varieties on incidence of insect pests of lentil. The analysis of variance (ANOVA) of the data on number of pests per plant, number of healthy pod, infested pod and percentage of pod infestation in number, are given in Appendix III. The results have been presented and discussed, and possible explanations have been given under the following headings:

4.1 Insect incidence

Incidence of insect was recorded for the entire cropping season and aphid, white fly, jassid, pod borer, spider and lady bird beetle was observed. Per Plant data for the incidence of insect pests were counted and presented as follows-

4.1.1 Aphid

Aphid incidence due to sowing time, variety and their combination showed statistically significant variation (Table 2, 3, 4). In case of different sowing time, the lowest number of aphid per plant (4.07) was observed from S_3 (sowing on 26 November) followed (4.88) by S_2 (sowing on 16 November) having significant difference between them. On the other hand, the highest number of the aphid was obtained (5.48) from S_4 (sowing on 06 December) which was statistically identical (5.38) with S_1 (sowing on 06 November) (Table 2).The population of aphid was gradually increased with plant age and reached at the peak on 45 days after sowing and declined (Fig. 1). The highest population was found in S_4 (December 6). Similar trend was found in case of different varieties. However, the maximum population was observed for V_3 (BARI Masur-5) (Fig 2). For variety, the lowest number of aphid per plant (5.74) was found in V_1 (BARI Masur-3) followed by (4.97, 4.56 and 4.55) in V_2 (BARI Masur-4), V_4 (BARI Masur-6) and V_3 (BARI Masur-5), respectively (Table 3) and having no significance difference among them. Considering the combine effect of sowing time and variety, the lowest number of aphid per plant (3.67) was found in S_3V_3 (sowing on 26 November and BARI Masur-5), on the other hand the highest number (6.93) was recorded from S_1V_1 (sowing on 06 November and BARI Masur-3) (Table 4).These result supporters the findings of Hossain *et al*. (2006) aphid infestation was higher in late sowing and protection measures taken against aphids and this was also dependent on the different dates of sowing.

4.1.2 Whitefly

Sowing time, variety and their combination showed statistically significant variation in terms of whitefly incidence (Table 2, 3, 4). For different sowing time, the lowest number of whitefly per plant (1.89) was recorded from S_3 (sowing on 26 November). On the other hand, the highest number of whitefly (2.28) was obtained from S_4 (sowing on 06 December) which was statistically identical (2.26 and 2.11) with S_1 (sowing on 06 November) and S_2 (sowing on 16 November) (Table 2), respectively. The population of whitefly was gradually increased with plant age and reached at the peak on 45 days after sowing and declined (Fig. 3). The highest population was found in S_1 (November 6). Similar trend was found in case of different varieties. However, the maximum population was observed for V_2 (BARI Masur-4) (Fig 4). Considering different varieties, the lowest number of whitefly per plant (2.01) was found in V_3 (BARI Masur-5), which was statistically similar (2.03 and 2.14) with V_4 (BARI Masur-6) and V_2 (BARI Masur-4), respectively and the highest number of whitefly (2.37) was observed in V_1 (BARI Masur-3). In response to the combined effect of sowing time and different varieties, the lowest number of whitefly per plant (1.80) was recorded from S_3V_1 (sowing on 26 November and BARI Masur-3) and S_3V_3 (sowing on 26 November and BARI Masur-5), consequently the highest number (2.70) was obtained from S_1V_1 (sowing on 06 November and BARI Masur-3) (Table 4).

Table 2. Population of aphid, whitefly and jassid per plant at different sowing time

Sowing time	Number of sucking insects plant^{-1}		
	Aphid	Whitefly	Jassid
S_1	5.38 ab	2.26 a	3.30 a
S_2	4.88 b	2.11 a	3.00 a
S_3	4.07 c	1.89 b	2.55 b
S_4	5.48 a	2.28 a	3.30 a
$LSD_{(0.05)}$	0.543	0.167	0.305
Significance level	0.01	0.01	0.01
CV (%)	13.14	9.37	12.03

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

S_1: Sowing on 06 November	S_2: Sowing on 16 November
S_3: Sowing on 26 November	S_4: Sowing on 06 December

Table 3. Population of aphid, whitefly and jassid on different varieties of lentil

Variety	Number of sucking insects plant^{-1}		
	Aphid	Whitefly	Jassid
V_1	5.74 a	2.37 a	3.43 a
V_2	4.97 b	2.14 b	3.04 b
V_3	4.55 b	2.01 b	2.85 b
V_4	4.56 b	2.03 b	2.83 b
$LSD_{(0.05)}$	0.543	0.167	0.305
Significance level	0.01	0.01	0.01
CV(%)	13.14	9.37	12.03

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

V_1: BARI Masur-3	V_2: BARI Masur-4
V_3: BARI Masur-5	V_4: BARI Masur-6

Table 4. Effect of sowing time and different varieties on incidence of aphid, whitefly and jassid

Sowing time × Variety	Number of insects plant^{-1}		
	Aphid	Whitefly	Jassid
S_1V_1	6.93 a	2.70 a	4.03 a
S_1V_2	4.63 def	2.03 cd	2.90 bcde
S_1V_3	5.13 cde	2.13 bcd	3.10 bcd
S_1V_4	4.83 cdef	2.17 bcd	3.17 bcd
S_2V_1	5.70 bcd	2.37 abc	3.43 abc
S_2V_2	4.90 cdef	2.13 bcd	2.93 bcde
S_2V_3	4.43 ef	2.00 cd	2.90 bcde
S_2V_4	4.47 def	1.93 d	2.73 cde
S_3V_1	3.87 ef	1.80 d	2.27 e
S_3V_2	4.40 ef	1.97 d	2.77 cde
S_3V_3	3.67 f	1.80 d	2.50 de
S_3V_4	4.37 ef	2.00 cd	2.67 de
S_4V_1	6.47 ab	2.60 a	3.97 a
S_4V_2	5.93 abc	2.43 ab	3.57 ab
S_4V_3	4.97 cde	2.10 bcd	2.90 bcde
S_4V_4	4.57 def	2.00 cd	2.77 cde
$LSD_{(0.05)}$	1.086	0.334	0.610
Significance level	0.05	0.05	0.01
CV (%)	13.14	9.37	12.03

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

S_1: Sowing on 06 November	V_1: BARI Masur-3
S_2: Sowing on 16 November	V_2: BARI Masur-4
S_3: Sowing on 26 November	V_3: BARI Masur-5
S_4: Sowing on 06 December	V_4: BARI Masur-6

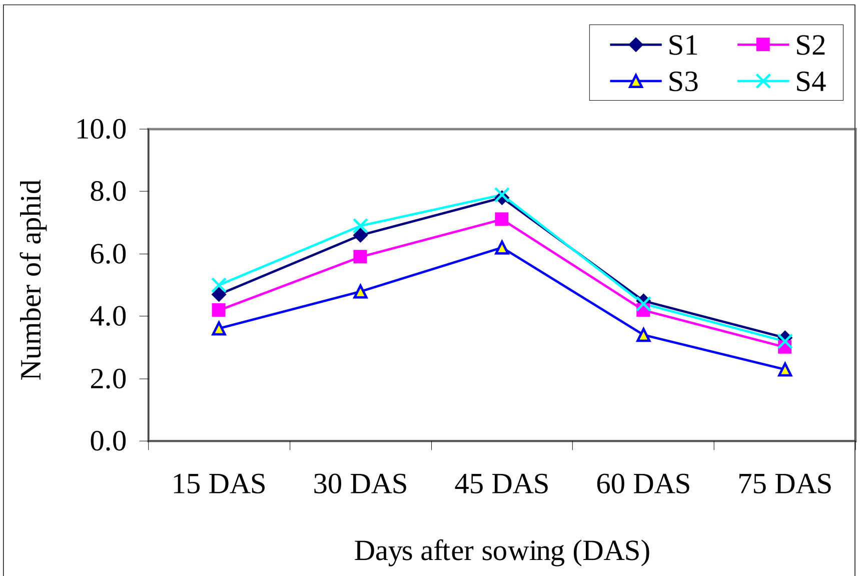

Figure 1. Population trend of aphid on different sowing times

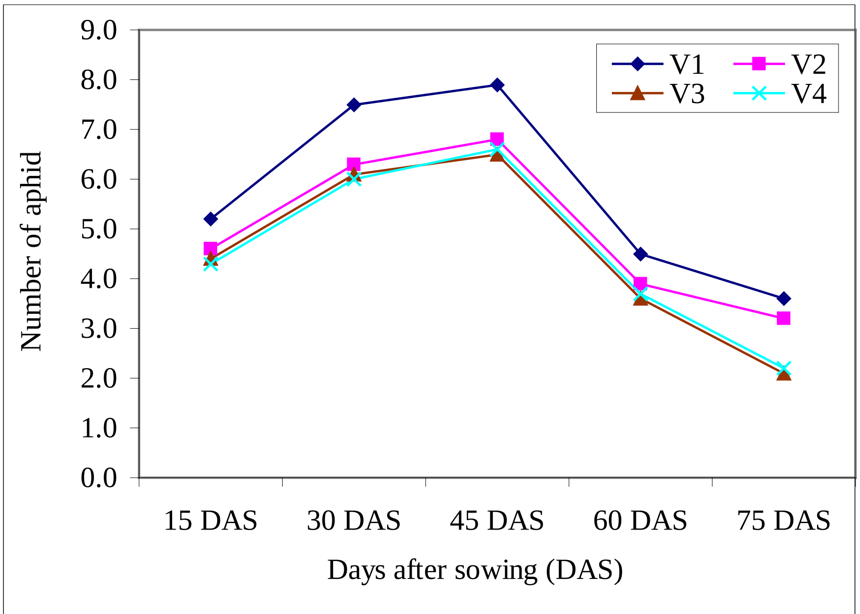

Figure 2. Population trend of aphid on different varieties

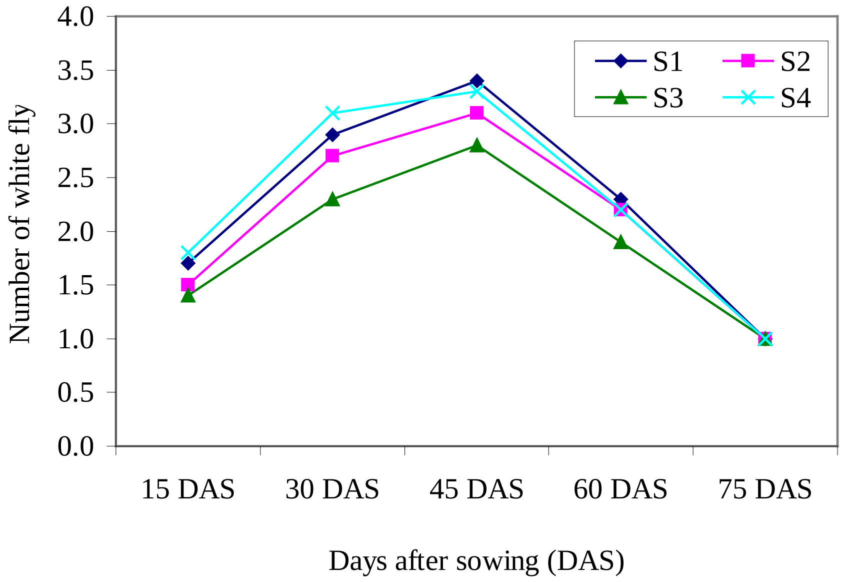

Figure 3. Population trend of white fly on different sowing times

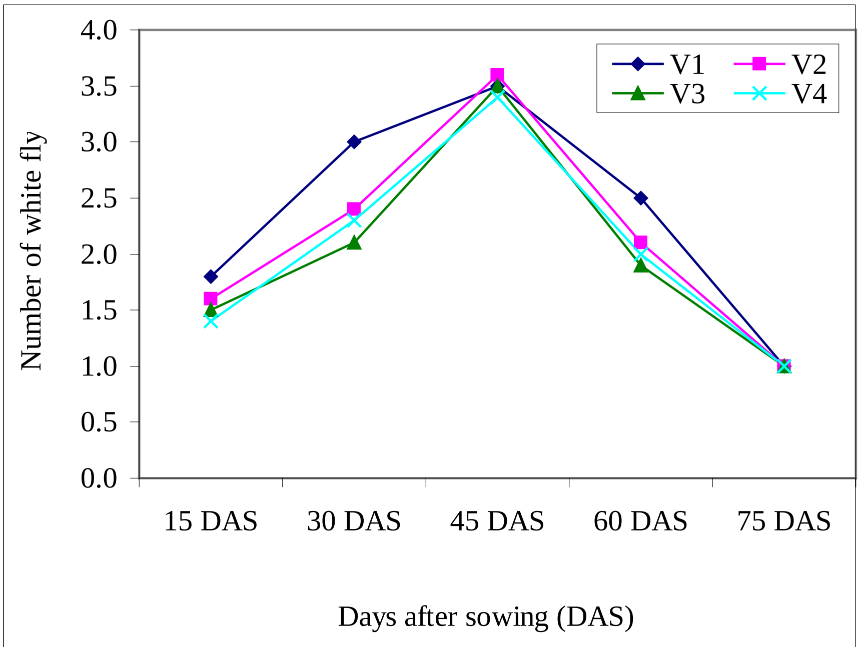

Figure 4. Population trend of white fly on different varieties

4.1.3 Jassid

A significant difference was observed for jassid incidence due to sowing time, variety and their combination (Table 2, 3, 4). In different sowing time, the lowest number of jassid per plant (2.55) was found in S_3 (sowing on 26 November), whereas the highest number (3.30) was recorded from S_1 (sowing on 06 November) and S_4 (sowing on 06 December) which was statistically identical (3.00) with S_2 (sowing on 16 November) (Table 2), respectively. The population of jassid was gradually increased with plant age and reached at the peak on 45 days after sowing and then declined (Fig. 5). The highest population was found in S_4 (December 6). Similar trend was found in case of different varieties. However, the maximum population was observed for V_1 (BARI Masur-3) (Fig 6). For different varieties, the lowest number of jassid per plant (2.83) was observed from V_4 (BARI Masur-6), which was statistically similar (2.85 and 3.04) with V_3 (BARI Masur-5) and V_2 (BARI Masur-4), while the highest number (3.43) was recorded in V_1 (BARI Masur-3) (Table 3), respectively. In case of combined effect of sowing time and different varieties, the lowest number of jassid per plant (2.27) was found in S_3V_1 (sowing on 26 November and BARI Masur-3) and S_3V_3 (sowing on 26 November and BARI Masur-5) and the highest number (4.03) was observed from S_1V_1 (sowing on 06 November and BARI Masur-3) (Table 4), respectively.

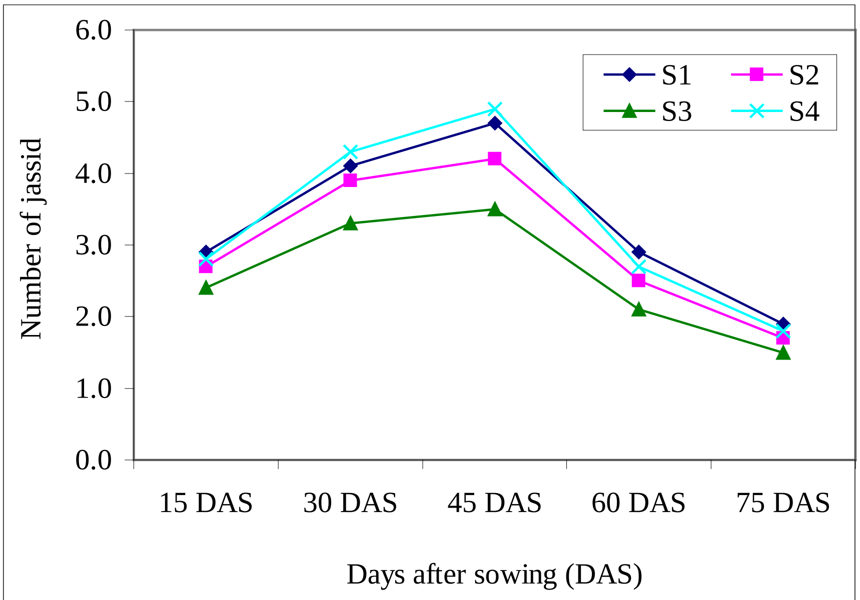

Figure 5. Population trend of jassid on different sowing times

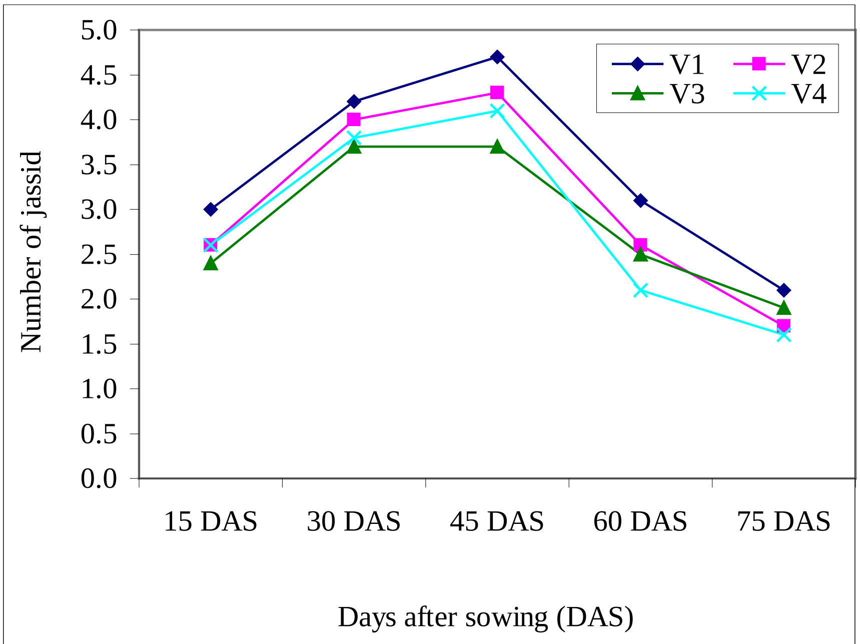

Figure 6. Population trend of jassid on different varieties

4.1.4 Pod borer

Statistically significant variation was recorded for pod borer incidence due to sowing time, variety and their combination (Table 5, 6, 7). For different sowing time, the lowest number of pod borer per plant (1.88) was recorded from S_3 (sowing on 26 November), again the highest number (2.42) was obtained in S_1 (sowing on 06 November) and S_4 (sowing on 06 December) which was statistically identical (2.26) with S_2 (sowing on 16 November) (Table 5), respectively having significant difference among them. In case of variety, the lowest number of pod borer per plant (2.07) was observed from V_4 (BARI Masur-6), which was statistically similar (2.12 and 2.25) with V_3 (BARI Masur-5) and V_2 (BARI Masur-4), whereas the highest number (2.54) was recorded in V_1 (BARI Masur-3) (Table 6), respectively. In response to the combined effect of sowing time and variety, the lowest number of pod borer (1.67) was recorded from S_3V_1 (sowing on 26 November and BARI Masur-3), while the highest number (3.00) was found in S_1V_1 (sowing on 06 November and BARI Masur-3) (Table 7). The results supported the findings Jayaramiah and Babu (1990) pod damaged by pod borer varied significantly due to different sowing date.

Table 5. Effect of different sowing time on number of pod borer infested pod per plant of lentil

Sowing time	Number of pod borer infested pod plant^{-1}
S_1	2.42 a
S_2	2.26 a
S_3	1.88 b
S_4	2.42 a
$LSD_{(0.05)}$	0.240
Significance level	0.01
CV (%)	12.84

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

S_1: Sowing on 06 November	S_2: Sowing on 16 November
S_3: Sowing on 26 November	S_4: Sowing on 06 December

Table 6. Effect of different varieties on number of pod borer infested pod per plant of lentil

Variety	Number of pod borer infested pod plant^{-1}
V_1	2.54 a
V_2	2.25 b
V_3	2.12 b
V_4	2.07 b
$LSD_{(0.05)}$	0.240
Significance level	0.01
CV(%)	12.84

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

V_1: BARI Masur-3	V_2: BARI Masur-4
V_3: BARI Masur-5	V_4: BARI Masur-6

Table 7. Combined effect of different sowing time and varieties on number of pod borer infested pod per plant of lentil

Sowing time × Variety	Number of pod borer infested pod plant^{-1}
S_1V_1	3.00 a
S_1V_2	2.10 def
S_1V_3	2.33 bcde
S_1V_4	2.23 cde
S_2V_1	2.67 abc
S_2V_2	2.23 cde
S_2V_3	2.03 ef
S_2V_4	2.10 def
S_3V_1	1.67 f
S_3V_2	2.07 def
S_3V_3	1.87 ef
S_3V_4	1.90 ef
S_4V_1	2.83 ab
S_4V_2	2.60 abcd
S_4V_3	2.23 cde
S_4V_4	2.03 ef
$LSD_{(0.05)}$	0.480
Significance level	0.05
CV (%)	12.84

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

S_1: Sowing on 06 November	V_1: BARI Masur-3
S_2: Sowing on 16 November	V_2: BARI Masur-4
S_3: Sowing on 26 November	V_3: BARI Masur-5
S_4: Sowing on 06 December	V_4: BARI Masur-6

4.2 Pod bearing status by number and their infestation

4.2.1 Early fruiting stage

At early fruiting stage, for different sowing time, variety and their combined effect showed a statistically significant variation in number of healthy pods per plant (Appendix IV, Table 11, 12 and 13). In different sowing time, the maximum number of healthy pods per plant (17.73) was found in S_3 (sowing on 26 November), which was statistically similar (17.27) with S_2 (sowing on 16 November) and followed (16.00) by S_1 (sowing on 06 November), again the minimum number (14.40) was recorded from S_4 (sowing on 06 December). In case of variety, the maximum number of healthy pods per plant (17.01) was recorded from V_4 (BARI Masur-6), which was statistically similar (16.47) with V_3 (BARI Masur-5). On the other hand, the minimum number (15.79) was observed from V_1 (BARI Masur-3) which was statistically identical (16.12) with V_2 (BARI Masur-4). For the combined effect of sowing time and variety, the maximum number of healthy pods per plant (19.50) was found in S_3V_4 (sowing on 26 November and BARI Masur-6), while the minimum number (12.93) was obtained from S_4V_4 (sowing on 06 December and BARI Masur-6).

At early fruiting stage, statistically significant variation was recorded for different sowing time, variety and their combination in terms of infested pods per plant in number (Appendix IV, Table 11, 12 and 13). In the response of different sowing time, the minimum number of infested pods per plant was recorded from S_3 (1.29), which was statistically similar with S_2 (1.36) and followed by S_4 (1.43), while the maximum number was found in S_1 (1.47), respectively. In case of variety, the minimum number of healthy pods per plant was recorded from V_4 (1.30), which was statistically similar with V_3 (1.32) which was followed by V_2 (1.41), whereas the maximum number was recorded from V_1 (1.52). In response to the combined effect of sowing time and variety, the minimum number of healthy pods per plant was observed from S_3V_4 (1.07), while the maximum number was recorded from S_1V_1 (1.67).

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Table 8. Effect of different sowing time on incidence of pod borer at early, mid and late fruiting stage in terms of fruit per plant by number

Sowing time	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation
S_1	16.00 b	1.47 a	8.41 b	27.33 c	3.33 c	10.96 b	39.65 b	6.80 b	14.71 b
S_2	17.27 a	1.36 bc	7.34 c	29.55 b	3.57 b	10.80 b	46.99 a	6.03 c	11.40 c
S_3	17.73 a	1.29 c	6.84 d	31.03 a	3.73 a	10.74 b	48.14 a	6.13 c	11.33 c
S_4	14.40 c	1.43 ab	9.08 a	22.56 d	3.00 d	11.79 a	38.06 b	7.13 a	15.84 a
$LSD_{(0.05)}$	0.832	0.083	0.477	1.375	0.147	0.485	2.020	0.252	0.725
Significance level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.10	9.23	7.22	5.97	7.18	5.25	5.61	9.64	6.53

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

S_1: Sowing on 06 November	S_2: Sowing on 16 November
S_3: Sowing on 26 November	S_4: Sowing on 06 December

Table 9. Effect of different variety on incidence of pod borer at early, mid and late fruiting stage in terms of fruit per plant by number

Variety	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation
V_1	15.79 b	1.52 a	8.84 a	26.48 b	3.54 a	11.84 a	40.92 c	6.82 a	14.52 a
V_2	16.12 b	1.41 b	8.11 b	27.36 ab	3.42 ab	11.17 b	42.67 bc	6.51 b	13.35 b
V_3	16.47 ab	1.32 c	7.44 c	28.20 a	3.36 b	10.67 c	44.17 ab	6.45 b	12.88 bc
V_4	17.01 a	1.30 c	7.29 c	28.42 a	3.31 b	10.61 c	45.08 a	6.31 b	12.53 c
$LSD_{(0.05)}$	0.832	0.083	0.477	1.375	0.147	0.485	2.020	0.252	0.725
Significance level	0.05	0.01	0.01	0.05	0.05	0.01	0.01	0.01	0.01
CV(%)	6.10	9.23	7.22	5.97	7.18	5.25	5.61	9.64	6.53

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

V_1: BARI Masur-3	V_2: BARI Masur-4
V_3: BARI Masur-5	V_4: BARI Masur-6

Table 10. Effect of different sowing time and varieties on incidence of pod borer at early, mid and late fruiting stage in terms of fruit per plant by number

Sowing time × Variety	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation
S_1V_1	15.43 ef	1.67 a	9.75 ab	26.37 de	3.50 bcde	11.75 abcd	37.63 ghi	7.27 ab	16.21 ab
S_1V_2	15.47 ef	1.50 abcd	8.88 bcde	24.50 ef	3.27 def	11.91 abc	38.30 fghi	6.50 cde	14.65 bcd
S_1V_3	16.03 def	1.17 gh	6.77 hi	28.83 cd	3.27 def	10.17 f	40.13 fgh	6.73 cd	14.38 cd
S_1V_4	17.07 bcde	1.53 abc	8.24 defg	29.63 bc	3.30 cdef	10.02 f	42.53 def	6.70 cd	13.62 d
S_2V_1	16.10 def	1.47 bcde	8.40 cdef	27.50 cde	3.57 abcd	11.49 abcde	44.90 cde	6.20 def	12.13 e
S_2V_2	18.00 abc	1.40 cdef	7.23 ghi	29.33 bcd	3.77 ab	11.40 bcde	45.57 cd	5.83 f	11.35 ef
S_2V_3	16.43 cde	1.30 efg	7.33 ghi	29.23 bcd	3.33 cdef	10.23 f	47.37 abc	6.10 ef	11.43 ef
S_2V_4	18.53 ab	1.27 fg	6.40 i	32.13 ab	3.60 abcd	10.07 f	50.13 ab	6.00 ef	10.69 ef
S_3V_1	17.20 bcde	1.33 defg	7.20 ghi	29.30 bcd	3.83 ab	11.58 abcd	46.30 bcd	6.40 def	12.15 e
S_3V_2	16.63 cde	1.30 efg	7.26 aghi	30.60 bc	3.57 abcd	10.43 ef	45.70 bcd	6.13 ef	11.85 ef
S_3V_3	17.57 bcd	1.47 bcde	7.71 fgh	30.07 bc	3.63 abc	10.79 def	48.90 abc	5.97 ef	10.89 ef
S_3V_4	19.50 a	1.07 h	5.19 j	34.13 a	3.87 a	10.17 f	51.67 a	6.00 ef	10.41 f
S_4V_1	14.43 fg	1.60 ab	9.99 a	22.77 f	3.27 def	12.55 a	34.87 i	7.43 ab	17.58 a
S_4V_2	14.40 fg	1.43 bcdef	9.05 abcd	25.00 ef	3.07 f	10.93 cdef	41.13 efg	7.57 a	15.56 bc
S_4V_3	15.83 def	1.37 cdef	7.95 efg	24.67 ef	3.20 ef	11.48 abcde	40.27 fgh	7.00 bc	14.82 bcd
S_4V_4	12.93 g	1.33 defg	9.34 abc	17.80 g	2.47 g	12.19 ab	35.97 hi	6.53 cde	15.41 bc
$LSD_{(0.05)}$	1.664	0.167	0.954	2.750	0.294	0.970	4.041	0.503	1.450
Significance level	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.05	0.05
CV(%)	6.10	9.23	7.22	5.97	7.18	5.25	5.61	9.64	6.53

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

S_1: Sowing on 06 November	S_3: Sowing on 26 November	V_1: BARI Masur-3	V_3: BARI Masur-5

S_2: Sowing on 16 November	S_4: Sowing on 06 December	V_2: BARI Masur-4	V_4: BARI Masur-6

At early fruiting stage, percentage of pod infestation showed a statistically significant variation for different sowing time, variety and their combination (Appendix IV, Table 11, 12 and 13). In different sowing time, the lowest pod infestation in number was observed from S_3 (6.84%), followed by S_2 (7.34%), again the highest infestation was found in S_4 (9.08%) which was followed by S_1 (8.41%). Due to variety, the lowest pod infestation in number was found in V_4 (7.29%), which was statistically similar with V_3 (7.44%) and followed by V_2 (8.11%), whereas the highest infestation in number was found in V_1 (8.84%). In response to the combined effect of sowing time and variety, the lowest pod infestation in number was observed from S_3V_4 (5.19%), on the contrary the highest infestation was obtained from S_4V_1 (9.99%), respectively.

4.2.2 Mid fruiting stage

At mid fruiting stage, for different sowing time, variety and their combined effect showed statistically significant differences in number of healthy pods per plant (Appendix IV, Table 11, 12 and 13). In response to different sowing time, the maximum number of healthy pods per plant (31.03) was obtained from S_3 (sowing on 26 November), which was closely followed (29.55) by S_2 (sowing on 16 November). On the other hand, the minimum number (22.56) was found from S_4 (sowing on 06 December) which was closely followed (27.33) by S_1 (sowing on 06 November). In case of variety, the maximum number of healthy pods per plant (28.42) was found in V_4 (BARI Masur-6), which was statistically similar (28.20 and 27.36) with V_3 (BARI Masur-5) and V_2 (BARI Masur-4), whereas the minimum number (26.48) was found in V_1 (BARI Masur-3). For the combined effect of sowing time and variety, the maximum number of healthy pods per plant (34.13) was recorded from S_3V_4 (sowing on 26 November and BARI Masur-6), whereas the minimum number (17.80) was recorded from S_4V_4 (sowing on 06 December and BARI Masur-6), respectively.

At mid fruiting stage, statistically significant variation was recorded for different sowing time, variety and their combined effect in number of infested pods per plant (Appendix IV, Table 11, 12 and 13). In response of different sowing time, the minimum number of infested pods per plant was observed from S_4 (3.00), which was closely followed by S_1 (3.33), again the maximum number was recorded from S_3 (3.73) which was closely followed by S_2 (3.57). In case of variety, the minimum number of infested pods per plant was found from V_4 (3.31), which was statistically similar with V_3 (3.36) and V_2 (3.42), while the maximum number was obtained from V_1 (3.54). For the combined effect of sowing time and variety, the minimum number of healthy pods per plant was found in S_4V_4 (2.47) and the maximum number was obtained from S_3V_4 (3.87).

At mid fruiting stage, a statistically significant variation was found for different sowing time, variety and their combined effect in terms of percentage of pod infestation (Appendix IV, Table 11, 12 and 13). In case of different sowing time, the lowest pod infestation was found in S_3 (10.74%), followed by S_2 (10.80%) and S_1 (10.96%), consequently the highest infestation was found in S_4 (11.79%). Due to variety, the lowest pod infestation was observed from V_4 (10.61%), which was statistically similar with V_3 (10.67%) and closely followed by V_2 (11.17%), whereas the highest infestation was obtained from V_1 (11.84%). Regarding the combined effect of sowing time and variety, the lowest pod infestation was recorded from S_1V_4 (10.02%), again the highest infestation was observed from S_4V_1 (12.55%).

4.2.3 Late fruiting stage

At late fruiting stage, for different sowing time, variety and their combined effect showed a statistically significant variation in number of healthy pods per plant (Appendix IV, Table 11, 12 and 13). In response to different sowing time, the maximum number of healthy pods per plant (48.14) was found from S_3 (sowing on 26 November), which was statistically similar (46.99) with S_2 (sowing on 16 November), while the minimum number (38.06) was found from S_4 (sowing on 06 December) which was statistically identical (39.65) with S_1 (sowing on 06 November). In case of variety, the maximum number of healthy pods per plant (45.08) was recorded from V_4 (BARI Masur-6), which was statistically similar

(44.17) with V_3 (BARI Masur-5), whereas the minimum number (40.92) was obtained from V_1 (BARI Masur-3) which was statistically identical (42.67) with V_2 (BARI Masur-4). In case of interaction effect of sowing time and variety, the maximum number of healthy pods per plant (51.67) was found from S_3V_4 (sowing on 26 November and BARI Masur-6), while the minimum number (34.87) was observed from S_4V_1 (sowing on 06 December and BARI Masur-3).

At late fruiting stage, in number of infested pods per plant showed statistically significant differences for different sowing time, variety and their combination (Appendix IV, Table 11, 12 and 13). For different sowing time, the minimum number of infested pods per plant was obtained from S_2 (6.03), which was statistically similar with S_3 (6.13) and closely followed by S_1 (6.80), whereas the maximum number was found in S_4 (7.13). In case of variety, the minimum number of healthy pods per plant was found in V_4 (6.31), which was statistically similar with V_3 (6.45) and V_2 (6.51), while the maximum number was observed from V_1 (6.82). In response to the interaction effect of sowing time and variety,the minimum number of healthy pods per plant was recorded from S_2V_2 (5.83) and the maximum number was found from S_4V_2 (7.57), respectively.

At late fruiting stage, for different sowing time, variety and their combined effect showed significant differences in percentage of pod infestation (Appendix IV,

Table 11, 12 and 13). For different sowing time, the lowest pod infestation was found from S_3 (11.33%), which was statistically similar with S_2 (11.40%), again the highest infestation was recorded from S_4 (15.84%) which was followed by S_1 (14.71%). In case of variety, the lowest pod infestation was recorded from V_4 (12.53%), which was statistically similar with V_3 (12.88%) and closely followed by V_2 (13.5%), whereas the highest infestation in number was obtained from V_1 (14.52%). For response to the combined effect of sowing time and variety, the lowest pod infestation was found from S_3V_4 (10.41%). On the other hand, the highest infestation was recorded from S_4V_1 (17.58%).

4.1.5 Spider

Spider incidence showed statistically significant variation due to sowing time, variety and their combination (Appendix III). For different sowing time, the lowest number of spider per plant (2.00) was recorded from S_3 (sowing on 26 November) followed (2.33) by S_2 (sowing on 16 November), whereas the highest number (2.73) was recorded from S_1 (sowing on 06 November) followed (2.57) by S_4 (sowing on 06 December) (Table 8), respectively. The population of spider was gradually increased with plant age and reached at the peak on 45 days after sowing and declined (Fig. 7). The highest population was found in S_4 (December 6). Similar trend was found in case of different varieties. However, the maximum population was observed for V_3 (BARI Masur-5) (Fig 8) In case of variety, the lowest number of spider per plant (2.31) was recorded from V_1 (BARI Masur-3), which was statistically similar (2.36 and 2.42) with V_4 (BARI Masur-6) and V_2 (BARI Masur-4), while the highest number of spider (2.54) was recorded from V_3 (BARI Masur-5) (Table 9). Considering the combined effect of sowing time and variety, the lowest number of spider per plant (1.47) was observed in S_3V_1 (sowing on 26 November and BARI Masur-3), whereas the highest number (2.87) was recorded in S_1V_1 (sowing on 06 November and BARI Masur-3) (Table 10).

Table 11 Population of spider and lady bird beetle per plot of lentil at different sowing time

Table 11. Population of spider and lady bird beetle per plot of lentil at different sowing time

Sowing time	Number of predators plot^{-1}	
	spider	lady bird beetle
S_1	2.73 a	4.54 a
S_2	2.33 c	3.90 b
S_3	2.00 d	2.69 c
S_4	2.57 b	4.46 a
$LSD_{(0.05)}$	0.147	0.461
Significance level	0.01	0.01
CV(%)	7.34	14.18

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

S_1: Sowing on 06 November	S_2: Sowing on 16 November
S_3: Sowing on 26 November	S_4: Sowing on 06 December

Table 12. Population of spider and lady bird beetle per plot at different varieties of lentil

Variety	Number of predators $plot^{-1}$	
	spider	lady bird beetle
V_1	2.31 b	4.41 a
V_2	2.42 ab	3.77 bc
V_3	2.54 a	3.44 c
V_4	2.36 b	3.97 ab
$LSD_{(0.05)}$	0.147	0.461
Significance level	0.05	0.01
CV(%)	7.34	14.18

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

V_1: BARI Masur-3	V_2: BARI Masur-4
V_3: BARI Masur-5	V_4: BARI Masur-6

Table 13. Effect of different sowing time and different varieties on population of spider and lady bird beetle

Sowing time × Variety	No.of spider plot^{-1}	No. of lady bird beetle plot^{-1}
S_1V_1	2.87 a	5.17 ab
S_1V_2	2.57 abcd	4.07 cde
S_1V_3	2.83 ab	4.67 abc
S_1V_4	2.63 abc	4.27 bcd
S_2V_1	2.30 cdef	4.63 abc
S_2V_2	2.27 def	3.63 cde
S_2V_3	2.50 bcde	3.27 def
S_2V_4	2.27 def	4.07 cde
S_3V_1	1.47 g	2.30 fg
S_3V_2	2.07 f	3.30 de
S_3V_3	2.27 def	2.10 g
S_3V_4	2.20 ef	3.07 efg
S_4V_1	2.60 abcd	5.53 a
S_4V_2	2.77 ab	4.07 cde
S_4V_3	2.57 abcd	3.73 cde
S_4V_4	2.33 cdef	4.50 bc
$LSD_{(0.05)}$	0.294	0.921
Significance level	0.01	0.01
CV(%)	7.34	14.18

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

S_1: Sowing on 06 November	V_1: BARI Masur-3
S_2: Sowing on 16 November	V_2: BARI Masur-4
S_3: Sowing on 26 November	V_3: BARI Masur-5
S_4: Sowing on 06 December	V_4: BARI Masur-6

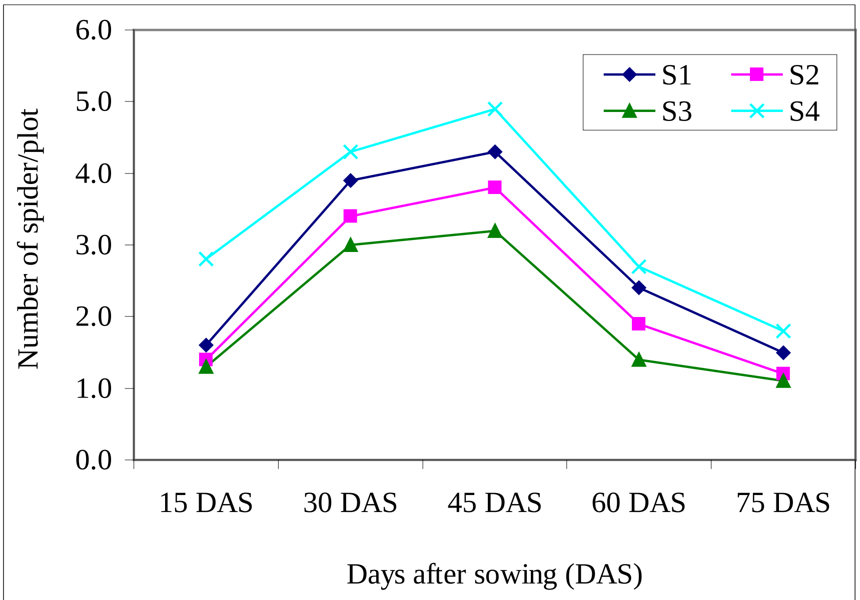

Figure 7. Population trend of spider on different sowing times

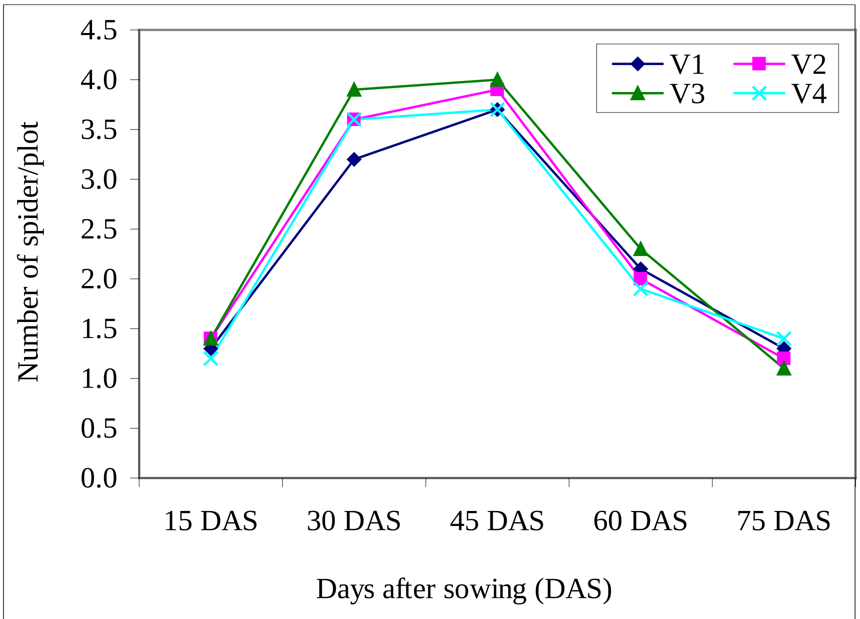

Figure 8. Population trend of spider on different varieties

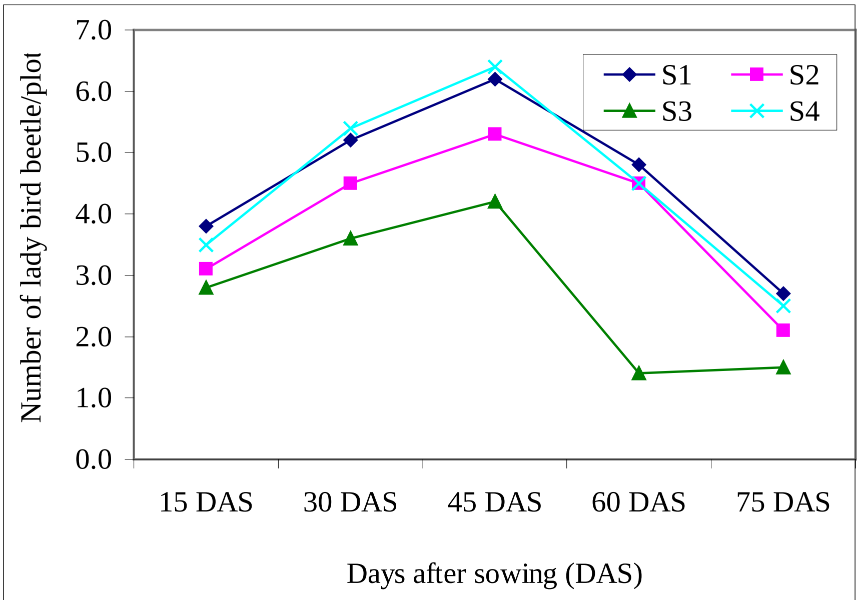

Figure 9. Population trend of lady bird beetle on different sowing times

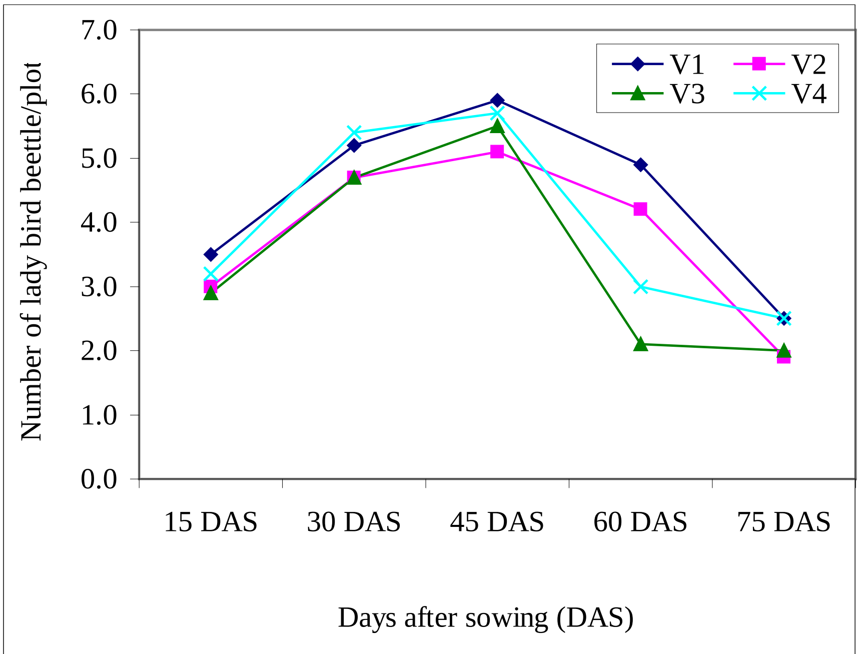

Figure 10. Population trend of lady bird beetle on different varieties

4.1.6 Lady bird beetle

Sowing time, the lowest number of lady bird beetle per plot (2.69) was obtained from S_3 (sowing on 26 November) which was followed (3.90) by S_2 (sowing on 26 November), consequently the highest number (4.54) was attained from S_1 (sowing on 06 November) which was statistically identical (4.46) with S_4 (sowing on 06 December) (Table 8). The population of lady bird beetle was gradually increased with plant age and reached at the peak on 45 days after sowing and declined (Fig. 9). The highest population was found in S_4 (December 6). Similar trend was found in case of different varieties. However, the maximum population was observed for V_1 (BARI Masur-3) (Fig 10) In case of variety, the lowest number of lady bird beetle per plant (3.44) was observed from V_3 (BARI Masur-5), which was statistically similar (3.77) with V_2 (BARI Masur-4) and the highest number (4.41) from V_1 (BARI Masur-3) which was statistically similar with V_4 (BARI Masur-6) (Table 9). For the combined effect of sowing time and variety, the lowest number of lady bird beetle per plant (2.10) was recorded from S_3V_3 (sowing on 26 November and BARI Masur-5), while the highest number (5.53) from S_4V_1 (sowing on 06 December and BARI Masur-3) (Table 10).

Chapter V

Summary and Conclusion

SUMMARY AND CONCLUSION

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to find out the effect of sowing time and different varieties on incidence of insect pests of lentil (*Lens culinaris*) during the period from October 2008 to April 2009. The experiment comprised two factors, viz., Factor A: Sowing time (4 levels) - S_1: Sowing on 06 November, S_2: Sowing on 16 November, S_3: Sowing on 26 November and S_4: Sowing on 06 December; Factor B: Variety (4 levels) - V_1: BARI Masur-3, V_2: BARI Masur-4, V_3: BARI Masur-5 and V_4: BARI Masur-6. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on incidence of insect pests were recorded and the collected data were analyzed statistically and the mean differences were adjusted by Duncan's Multiple Range Test (DMRT).

Incidence of insect was recorded for the entire cropping season and aphid, white fly, jassid, pod borer, spider and lady bird beetle were observed. For different sowing time, the number of aphid, whitefly, jassid , pod borer, spider and lady bird beetle (4.07, 1.89, 2.55, 1.88, 2.00 and 2.69) was recorded from S_3 and respectively the highest number (5.48, 2.28, 3.30, 2.42, 2.57 and 4.46) from S_1. In case of variety, the number of aphid, whitefly, jassid, pod borer, spider and lady bird beetle (4.56, 2.03, 2.83, 2.07, 2.36 and 3.97) was recorded from V_4 again, respectively the highest number (5.74, 2.37, 3.43, 2.54, 2.31 and 4.41) from V_1.

At early, mid and late fruiting stage, for different sowing time, variety and their combined effect showed a statistically significant variation in number of healthy pods, infested pods per plant and percentage of infestation. At early fruiting stage for different sowing time, the lowest pod infestation in number was observed from S_3 (6.84%), again the highest from S_4 (9.08%). In case of variety, the lowest pod infestation in number was found from V_4 (7.29%), whereas the highest from V_1 (8.84%). In response to the combined effect of sowing time and variety, the lowest pod infestation in number was observed from S_3V_4 (5.19%), on the contrary the highest from S_4V_1 (9.99%). At mid fruiting stage for different sowing time, the lowest pod infestation was found from S_3 (10.74%) and the highest from S_4 (11.79%). In case of variety, the lowest pod infestation was observed from V_4 (10.61%), whereas the highest from V_1 (11.84%). In response to the combined effect of sowing time and variety, the lowest pod infestation was recorded from S_1V_4 (10.02%), again the highest from S_4V_1 (12.55%). At late fruiting stage, for different sowing time, the lowest pod infestation was found from S_3 (11.33%), again the highest from S_4 (15.84%) which was followed by S_1 (14.71%). In case of variety, the lowest pod infestation was recorded from V_4 (12.53%), whereas the highest from V_1 (14.52%). In response to the combined effect of sowing time and variety, the lowest pod infestation was found from S_3V_4 (10.41%) and the highest from S_4V_1 (17.58%).

It is concluded that the incidence and population of insect pests of lentil was very much dependent on the sowing time and variety. Both the sowing time S_4 (December 06) and variety V_1 (BARI Masur-3) received higher insect pests infestation than others. Hence, for ensuring less insect pests infestation, lentil should be sown in November 26 (sowing time S_3) and the best variety would be BARI Masur-6.

Considering the situation of the present experiment, further studies in the following areas may be recommended:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability;
2. Other sowing times may be included in the future study.

Chapter VI

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APPENDICES

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

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

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

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October 2008 to April, 2009

Month	*Air temperature (^oC)		*Relative humidity (%)	*Rainfall (mm)
	Maximum	Minimum		
October, 2008	29.18	18.26	81	39
November, 2008	25.82	16.04	78	00
December, 2008	22.4	13.5	74	00
January, 2009	24.5	12.4	68	00
February, 2009	27.1	16.7	67	30
March, 2009	31.4	19.6	54	11
April, 2009	33.2	21.1	61	88

* Monthly average,

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

Appendix III. Analysis of variance of the data on number of insects per plant as influenced by different sowing time and variety

Source of variation	Degrees of freedom	Mean square					
		Number of insects plant^{-1}					
		Aphid	Whitefly	Jassid	Pod borer	Spider	Lady bird beetle
Replication	2	0.072	0.016	0.083	0.012	0.033	0.517
Factor A (Sowing time)	3	4.977**	0.389**	1.508**	0.795**	1.191**	8.734**
Factor B (Variety)	3	3.759**	0.327**	0.909**	0.545**	0.121*	1.968**
Interaction (A×B)	9	1.097*	0.108**	0.408**	0.216*	0.159**	0.876**
Error	30	0.424	0.040	0.134	0.083	0.031	0.305

**Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on incidence of pod borer at early, mid and late fruiting stage in terms of fruit per plant by number as influenced by different sowing time and variety

Source of variation	Degrees of freedom	Early fruiting stage			Mid fruiting stage			Late fruiting stage		
		Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation
Replication	2	0.515	0.006	0.003	3.92	0.03	0.410	2.143	0.00	0.22

					1	3			5	2
Factor A (Sowing time)	3	26.629**	0.074**	12.382**	164.092**	1.191**	2.829**	311.342**	3.390**	63.857**
Factor B (Variety)	3	3.238*	0.115**	5.980**	9.382*	0.121*	3.907**	39.604**	0.571**	9.015**
Interaction (A×B)	9	3.851**	0.057**	2.244**	21.658**	0.159**	1.166**	14.166*	0.199*	2.636*
Error	30	0.996	0.010	0.327	2.720	0.031	0.338	5.872	0.091	0.756

**Significant at 0.01 level of probability; *Significant at 0.05 level of probability