EFFECT OF SOME INSECTICIDES AGAINST MAJOR INSECT PESTS OF BLACKGRAM

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EFFECT OF SOME INSECTICIDES AGAINST MAJOR INSECT PESTS OF BLACKGRAM

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Some Insecticides Against Major Insect Pests of Blackgram'** 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 *bonafide* research work carried out by **Sourav Goswami**, Registration number: **10-04022** 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, received during the course of this investigation has duly been acknowledged.

Dated: June, 2016
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DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted during the period from March to May, 2016 at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka to study the effect of some insecticides against major insect pests of blackgram. Blackgram variety BARI mash-3 (Hemantoo) was used as planting materials for the study. The experiment consists seven treatments as T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval; T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval; T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval; T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval; T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval; T_6: Neem oil @ 3 ml + Trix @ 5 ml at 10 days interval and T_7: Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on the incidence of different insect pests on blackgram, pod infestation, different yield attributes and yield were recorded and significant variation was recorded for different treatment. The lowest number of stem fly larvae/pupae per plant (0.33) was found from T_1, while the highest (4.67) from T_7. The lowest number of jassid per 10 leaves (1.22) was found from T_3, whereas the highest (9.39) from T_7. The lowest number of whitefly per 10 leaves (1.19) was found from T_3, while the highest (7.77) from T_7. The lowest number of jute hairy caterpillar per plant (1.07) was found from T_4, while the highest (3.87) from T_7. The lowest number of stink bugs per 10 leaves (1.27) was found from T_4, while the highest (5.27) from T_7. At early pod development stage, the lowest infestation (2.16%) was recorded in T_2 treatment, whereas the highest infestation (12.04%) in T_7 treatment. At mid pod development stage, the lowest infestation (3.09%) was recorded in T_2 treatment, while the highest (13.69%) in T_7 treatment. At late pod development stage, the lowest infestation (3.96%) was recorded in T_2 treatment but the highest (14.70%) in T_7 treatment. The highest yield per hectare (1.75 ton) was recorded in T_4 treatment, whereas the lowest (1.18 ton) in T_7 treatment. The highest benefit cost ratio (2.13) was estimated for T_3 treatment, while the lowest (1.45) from T_5 treatment. It was revealed that Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval was more effective against the major insect pests of blackgram.

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CHAPTER I

INTRODUCTION

Blackgram (*Vigna mungo* L.) belongs to the family Fabaceae, sub-family Faboideae is a self pollinating and widely cultivated legume locally known as maskalai (Naga *et al*., 2006). It is a deep rooted drought hardy crop, source of fodder, green mannuring, pluses and lavish iron and zinc rich minerals (Singh *et al*., 2013). The crop is resistant to adverse climatic conditions and improves the soil fertility by fixing atmospheric nitrogen in the soil. Blackgram originated in south and southeast Asia but widely cultivated in India, Pakistan, Bangladesh, Myanmar, Thailand, Philippines, China and Indonesia (Poehlman, 1991). It is an important pulse crop of Bangladesh and ranks the fourth position considering both acreage and production (MoA, 2014). This crop is grown in Bangladesh cropping systems as a mixed crop, cash crop, sequential crop. Besides, it is growing as sole crop under residual moisture conditions after the harvest of rice and also before and after the harvest of other summer crops under semi irrigated and dry land conditions (Parveen *et al*., 2011).

Blackgram is an excellent source of plant carbohydrates, protein and other nutrients. Generally, its grain contains 24% protein, 59% carbohydrates, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981 and Kaul, 1982). It grains also contains 154 mg calcium, 9.1 mg iron and 38 mg β-carotine per 100 g of split blackgram (Bakr *et al*., 2004). According to FAO (2013) recommendation, a minimum intake of pulse by a human should be 80 gm day^{-1}, whereas it is 7.92 g in Bangladesh (BBS, 2012). Bangladesh needs more than 2,299 thousand tons of pulses to meet the demand of the population at present situation (FAO, 2012; BBS, 2012). However, the country produced only 474 thousand tons which was only 29.53% of the total demand. In 2011-2012, the country produced only 18,000 tons of blackgram which was less than 5.26% of the immediate previous year. The acreage production of blackgram in Bangladesh is gradually declining day by day (BBS, 2012).

The average yield of blackgram is 0.7 t ha^{-1} which is incomparable with the average yield of developed countries of the world (BBS, 2012). Generally, it is cultivated with minimum tillage, local varieties with no or minimum fertilizers, no weed management and very early or very late sowing, no practicing of irrigation, no drainage facilities and also without pest management and all these factors are responsible for low yield of blackgram. A number of agronomic practices have been found to influence the yield of pulse crops. Of the several factors responsioble for such low yield undoubtely insect infestation is considered as one of the most important factor. A number of insect pests attack blackgram in the field. Among them, a. stemfly (Rahman, 1991; Mia, 1998; Prodhan *et al*., 2000), b. flea beetle, c. thrips, d. pod borer (Mia, 1998) are the major pests of blackgram in Bangladesh causing serious damage to the crop and reduction in yield. An average of 2.5 to 3.0 million tons of pulses is lost annually due to pest problems (Rabindra *et al*., 2004). The avoidable losses due to *Bemisia tabaci* (Gennadius) and other insect pests in blackgram have been reported to range from 17.42 to 71.0% at different locations (Saxena, 1983; Chhabra *et al*., 1981; Justin *et al*., 2015).

For management of blackgram insect pests, many options such as chemical, botanical, cultural, mechanical, biological etc. are available in our country. Among the different management practices the farmers of our country use different pesticides in controlling insect pests of blackgram. Pesticides are toxic chemicals designed to be deliberately released into the environment. Although each pesticide is meant to kill a certain pest, a very large percentage of pesticides reach a destination other than their target and they enter the air, water, sediments and even end up in our food. Non judicious use of pesticides results in a series of problems related to both loss of their effectiveness in the long run and certain externalities such as pollution and also health hazards (Justin *et al*., 2015). Like improper dose, incorrect time of insecticides application creates many problems like excessive residue, resistance development, killing of non-target organisms, pest resurgence etc. (Sreekanth *et al*., 2004).

However some insecticides are less toxic, more selective, and less harmful to arthropods biodiversity and the environment as well. Lal and Sachan (1987) reported that chemicals (pesticides) are widely used to combat the insect pest problem in pulses. Generally the farmers of Bangladesh do not spray chemicals to control insect pest complex of blackgram due to its low profit margin. For this reason, several chemicals for different insect pests may not be acceptable to growers although, they are highly reluctant to follow pest control measure. But when they used appropriate pesticides with proper dose, in correct time based on the incidence of specific insect pests then it would carry high profit margin. The use of appropriate pesticides may led to minimize certain well known drawbacks. Keeping these in views, it is necessary to know the incidence of major insect pests of blackgram.

Under the above perspective for the effective control blackgram pests the present study has been undertaken with fulfilling the following objectives-

1. To observe the incidence of major insect pests of blackgram production.
2. To find out the suitable insecticide(s) for the management of insect pests of blackgram.

CHAPTER II

REVIEW OF LITERATURE

2.1 Insect pest incidence in blackgram

Pulses until today provide the only high protein component of the average diet of the majority people of Bangladesh (Rahman *et al.*, 1988). Blackgram is one of the most promising pulse crops in Bangladesh and there are many constrains for it's low yield such as varietal aspect, climatic factors, management practices, insect pests and diseases. Among them insect pests is considered the important one. Rahman *et al*. (1981) listed the following insect pests that attack -

Common name	Scientific name	Order
Stem fly	*Ophiomyia phaseoli*	Diptera
Jassid	*Empoasca kerri*	Homoptera
Whitefly	*Bemisia tabaci*	Homoptera
Thrips	*Megalurothrips distalis*	Thysanoptera
Bean aphid	*Aphis craccivora*	Homoptera
Hairy caterpillar	*Spilarctia obliqua*	Lepidoptera
Leaf webber	*Laprosoma indicate*	Lepidoptera
Leaf miner	*Acrocerphos phacospora*	Lepidoptera
Epilachna beetle	*Epilachna spp.*	Coleoptera
Semi-loopers	*Diachrysia orochalcea*	Lepidoptera
Spotted pod borer	*Maruca vitrata*	Lepidoptera
Green bug	*Nezara viridula*	Homoptera
Bean lycaenidae	*Euchrysops cnejus*	Lepidoptera

Among the above listed insect pests, stemfly, jassid, whitefly, thrips, hairy caterpillar and pod borer are the major and most damaging insect pests of blackgram (Rahman *et al*., 1981; Gowda and Kaul, 1982).

Cataloguing of different insect pests occurring in black gram, screening of black gram genotypes against major insect pests and their incidence on black gram at three different sowing times were investigated by Justin *et al*. (2015) at Agricultural Research Station Farm, Tamil Nadu Agricultural University, Kovilpatti, Tuticorin District. Totally, 11 species of insect pests were identified in black gram ecosystem. Among the 10 black gram genotypes screened, KBG 06 016 recorded minimum population of leafhoppers during both the years and KBG 05 007 and KBG 06 021 showed minimum population of aphid during 2010–2011 and 2011–2012, respectively. The minimum damage by pod borer was noticed in KBG 04 003 and KBG 08 001 during 2010–2011 and 2011–2012, respectively. The minimum number of leafhoppers, aphids and pod borers were observed in monsoon, post-monsoon and pre-monsoon sown blackgram, respectively.

Stem fly

The stem fly is a serious pest of blackgram at seedling stage (Gupta and Sing, 1984) and has been identified as a major pest in India (Saxena, 1978). The adult bean fly deposits eggs in punctures of the leaf tissue, the first pair of leaves of bean seedlings being favorite sites for oviposition. The maggot bores into young stem and damages the stem. In young plants the larvae of the fly cause extensive tunneling. The freshly formed tunnels are silvery-white and difficult to locate. The older tunnels are dark brown in colour and contained faces. Due to the decaying of the surrounding pith area around the zig-zag tunnels, the old tunnels turned into straight ones (Singh and Singh, 1990). They do not make any exit hole (Sehgal *et al*., 1980). Infested seedlings frequently wilt and subsequently die. The growth of older plants become slowly stunted (Prodhan *et al*., 2000).

Jassid

Jassid is a serious pest of blackgram. The female adult insect lays a number egg singly on leaf. Eggs are oviposited into veins and leaf petioles of the blackgram plant (Chaudhary *et al*, 1980). The wingless nymphs feed on the plant while passing through several nymphal stages and later emerge as winged adults. Life cycles are completed in three to four weeks. Nymphs and adults generally feed on the underside of the leaf, sucking out the juice and injecting toxic saliva into the cells causing hopper burn. Infested plants are unthrifty and lack vigor and young plants may be stunted (Chhabra *et al*., 1981).

White fly

The adult whitefly is a tiny soft bodied and pale yellow, change to white within a few hours due to deposition of wax on the body and wings (Haider, 1996). Eggs are laid indiscriminately almost always on the under surface of the young leaves (Hirano *et al*., 1993). Eggs are pear shaped and 0.2 mm long. One female can lay upto 136 eggs in her life time (Baldev, 1988). The nymphs are pale, translucent white, oval, with convex dorsum and flat elongated ventral side. The whitefly adults and nymphs feed on the plant sap from the underside of the leaves. They secrete honeydew, which later helps the growth of sooty mould fungus thus reducing the photosynthetic area. The infested plants became weakened due to sucking of the plant sap from the leaves and also due to the reduction of photosynthesis of the infested plant parts (Naresh and Nene, 1980). Young plant may even be killed in case of severe whitefly infestation (Srivastava and Singh, 1976). The infested plant parts become yellowish, the leaves become wrinkle, curl downwards and eventually they fallen off. This happens mainly due to viral infection where the whitefly acts as a mechanical vector of many viral diseases.

Thrips

Thrips are another important pests in blackgram. They are small, slim-bodied insects with rasping-sucking mouthparts that puncture plant cells and suck out their contents. Thrips feed on flowers, petioles and stigmas; causing deformity of the inflorescence and premature flower shedding. Sachan (1986) has reported widespread thrips damage to blackgram flowers.

Hairy caterpillar

The name of the insect denotes that there are plenty of hairs on the body of the larval stage of the insect. Adult moth is straw colored and the front pair of wings contains black spot. The body of the larvae is orange colored with both ends are black. In about 15 to 20 days, the caterpillar is fully-grown and it measures 2.5 to 4.0 cm (Bakr, 1998). Hairy caterpillar is a widely distributed polyphagous insect pest. The hairy caterpillar attacks the tender leaves of the seedling after hatching and as a result, the growth of the seedling is ceased.

Pod borer

Pod borer is one serious preharvest pest of blackgram (Mia, 1988; Sehgal and Ujagir, 1988) and other tropical and sub-tropical countries. The adult moth of pod borer is dark brown in color. There is a white half circle spot on the front pair of wings. Hind pair of wings is grayish white in color and moth having light brown spots on the leaf. The larvae are yellowish in color. They enter into the inflorescence and start feeding the flowers, later they cripple leaves together making nets and nets with leaves, flowers and young pods. They remain inside the nets hiding themselves and eat the young seeds boring the pods. Bakr (1988) reported that the span of larval period may be 10-24 days.

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 widely distributed agricultural pests, occurring throughout Asia, Australia, New Zealand, Africa, southern Europe and many Pacific islands.

Egg

In general, the eggs of pod borers 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 yellow-white, glistening, changing to dark brown before hatching with 0.4 to 0.55 mm in diameter. The incubation period of the eggs is being 2 to 8 days in South Africa and 2.5 to 17 days in the United States and 2 to 5 days in India and it is longer in cold weather and shorter in hot weather conditions (Singh and Singh, 1975).

Larva

The newly hatched larva of pod borer is translucent and in color it is yellowish white with faint yellowish orange longitudinal lines. The larval duration varied from 21 to 40 days in California, 18 to 51 days in Ohio, while 8 to 12 days in the Punjab, India (Singh and Singh, 1975) on the same host. The larval stage lasted for 21 to 28 days on chickpea; 2 to 8 days on maize silk; 33.6 days on sunflower, bitter gourd. 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. The development of the larva considerably effected by the temperature. The head of the pod borer is reddish brown. Thoracic, anal shields and legs were brown but the setae dark brown. 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 (Singh and Singh, 1975).

There are normally six larval instars in pod borer (Bhatt and Patel, 2001). But during the cold season of low temperature, when larval development is generally prolonged there is seven instars regularly found in Southern Rhodesia.

Pupa

The pod borer pupa undergoes a facultative diapauses. The non-diapause pupal period for pod borer was recorded as 14 to 40 days in the Sudan Gezira, 14 to 57 days in Southern Rhodesia, 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 (Bhatt and Patel, 2001). The pupa is generally 14 to 18 mm long, mahogany-brown, smooth-surfaced and rounded both anteriorly and posteriorly with two tapering parallel spines at the posterior tip (Singh and Singh, 1975).

Adult

Generally the female pod borer is a stout-bodied moth, 18 to 19 mm long, with a wingspan of 40 mm whereas 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 although 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 died when only 3 to 6 days old (Jayaraj, 1982).

The longevity of laboratory reared males are 3.13 ± 0.78, whereas the females are 6.63 ± 0.85 days (Singh and Singh, 1975). Bhatt and Patel (200l) reported that adult period in male ranged from 8 to 11 days with an average of 9.15 ± 0.90 days but in females it was 10 to 13 days with an average of 11.40 ± 0.91 days.

Generations

The generation of pod borer varied based on locations, environmental conditions and host plants. Singh and Singh (1975) reported that pod borer 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 blackgram in July to August.

Mating and oviposition

On many host plants, the eggs were laid by pod borer on the lower surface of the leaves, along the midrib. Eggs were also laid on buds, flowers and in between the calyx and fruit. The eggs were laid in singly, late in the evening, mostly after 21.00 hour to midnight.

Singh and Singh (1975) found that the pre-oviposition period of pod borer ranged from 1 to 4 days, oviposition period 2 to 5 days and post-oviposition period 1 to 2 days in normal condition. 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.

Roome (1975) studied the mating activity of pod borer and observed that mating activity may vary from 02.00 to 04.00 hour. The males flew above the crop while the females were stationary and released a pheromone. During this period males were highly active condition and assembled around females.

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 throughout the year ovipositing on the host crops and weeds with flowers.

Bhatt and Patel (2001) 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. 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.

2.2 Role of chemicals on insect pests management of blackgram and other similar pulse crops

The avail techniques for controlling insect pests are conveniently categorized in order of complexity as cultural, mechanical, physical, biological, chemical, genetic, regulatory and biotechnological methods. Among these techniques, chemical method is widely and frequently used. However, very limited research reports on the performance of different chemical on the controlling of major insect pests of blackgram have been done in various part of the world including Bangladesh and the work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works conducted at home and abroad in this aspect re reviewed under the following headings:

Justin *et al*. (2015) conducted field experiments to evaluate the efficacy of different insecticidal treatments against aphid, *Aphis craccivora* Koch, leafhopper, *Empoasca kerri* Pruthi, defoliator, *Spodoptera litura* (Fab.) and pod borer, *Helicoverpa armigera* (Hub.) on black gram. The results showed that seed treatment with thiamethoxam 25 WG @ 3 g/kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l recorded the lowest population of aphids (1.60, 1.45 No./plant) and leafhoppers (2.36, 2.12 No./plant) followed by spraying of imidacloprid 17.8 SL @ 0.4 ml/l with 83.96, 87.45 kg and 66.13, 71.61 per cent reduction over control, respectively after second round of spraying in the fields trials I and II. Indoxacarb 14.5 SC @ 1 ml/l provided an effective control of *S. litura* and *H. armígera* which recorded 0.04, 0.00 and 0.09, 0.03 No. of larvae/plant at 7th day after the second application in the field trial I and II, respectively, which was at par, with sponsored 45 SC @ 0.4 ml/l (0.08, 0.07 and 0.13, 0.13 at 7 DAT of second application) but was significantly better than the untreated control. Thus, seed treatment with thiamethoxam 25 WG @ 3 g/kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l and indoxacarb 14.5 SC @ 1 ml/l proved effective against sucking pests and borers of blackgram, respectively and can be recommended for their use in blackgram ecosystem.

A field experiment was conducted by Mandal *et al*. (2013) to evaluate the efficacy of some insecticides against spotted pod borer (*Maruca testulalis*) of blackgram. Insecticides evaluated for the purpose were azadirachtin1500 ppm @ 1.5 l ha^{-1}, endosulfan 35 EC @ 300 g a.i. ha^{-1}, triazophos 40 EC @ 250 g a.i. ha^{-1}, thiamethoxam 25 WG @ 40 g a.i. ha^{-1}, lambda cyhalothrin 5 EC @ 40 g a.i. ha^{-1}, indoxacarb14.5 SC @ 75 g a.i. ha^{-1}, and imidacloprid 17.8 SL @ 30 g a.i. ha^{-1}. Two round of spray of insecticides were given at fifteen days interval. The most effective insecticide evaluated against spotted pod borers was indoxacarb. Highest incremental cost benefit ratio 21.53 was observed with triazophos 40 EC @ 250 g a.i ha^{-1}.

Dubey (2007) carried out an experiment to study the efficacy of *Trichoderma viride* (IARIP-2), *Pongamia glabra* [*P. pinnata*] cake and leaf extract and carboxin in different combinations and modes of application in field trials at New Delhi, India. Fifty-four combinations of different treatments were applied through soil, seed and foliar spray in the experimental field conditions. Integrated soil application of *P. glabra* cake (200 kg/ha), seed treatment with *T. viride* (2 g/kg seed) + carboxin (1 g/kg seed) + *Rhizobium* sp. (25 g/kg seed) and foliar spray of *P. glabra* leaf extract (10%) suppressed disease severity significantly and the highest value was 92.7%. This treatment also increased seed germination about 32.4%, improved plant vigour and enhanced production around 49.2%. The same combination excluding carboxin was also effective and could be an option for organic production of mungbean cultivation. The integration of any two modes of applications of the treatments was superior in comparison to any single mode of application.

Ganapathy and Karuppiah (2004) conducted a field experiment to determine the efficacy of new insecticides against whitefly, mungbean yellow mosaic virus (MYMV) and urdbean leaf crinkle virus (ULCV) in mungbean cv. CO-4 during summer seasons in Tamil Nadu, India. The treatments comprised of seed treatment with 5 g imidacloprid/kg seed (T_1); seed treatment with 5 g thiamethoxam/kg seed (T_2); 0.25 ml imidacloprid/litre at 15 days after sowing

(DAS; T_3); 0.2 g thiamethoxam/litre at 15 DAS (T_4); 0.1 g acetamiprid/litre at 15 DAS (T_5); 0.25 ml fipronil/litre at 15 DAS (T_6); 2 ml dimethoate/litre at 15 DAS (T_7); 0.5 ml cypermethrin/litre at 15 DAS (T_8); 1 ml neem oil/litre at 15 DAS (T_9); water spray (control; T_{10}). The findings revealed that highest whitefly population was observed at 25, 35 and 50 DAS and found that T_4 effectively decreased whitefly population in field conditions and gave the highest yield of 800 kg/ha.

Rajnish *et al*. (2004) reported that whitefly population was higher in *Vigna mungo* than mungbean [*Vigna radiata*] crop season in Uttar Pradesh, India. From the findings they reported that kharif season crop of mung and and urdbean were more vulnerable to the attack of whitefly. In both the crops the peak population of whitefly was recorded in first fortnight of May and second fortnight of September. Temperature and sunshine hours were generally favourable for whitefly and have a positive correlation with incidence of white fly. Of the 50 entries tested, 16 entries of urdbean were superior as whitefly population was lower than the standard control and whitefly population varied between 0.85 and 8.26 per plant as against 8.46 per plant on the standard control.

Sreekanth *et al*. (2004) evaluated the efficacy of imidacloprid, thiamethoxam, acetamiprid, fipronil, dimethoate, fenvalerate and azadirachtin in controlling *T. palmi*, the vector of peanut bud necrosis virus (PNBV) infecting mungbean in a field experiment. All the insecticides tested reduced *T. palmi* population and PBNV incidence, with imidacloprid treatment resulting in the highest *T. palmi* control and that is the 57.47% and 67.41% and consequently, the lowest PBNV incidence around 19.11% and 29.74% was recorded during the kharif and rabi seasons, respectively.

Ram and Singh (1999) carried out an experiment to study the management of insect pests of mungbean with insecticides using seed treatment and pre-sowing soil application followed by foliar application at Pantnagar, India. Seed treatment with the chemicals of carbosulfan, monocrotophos, dimethoate, phosphamidon, methyl-o-demeton, methomyl and chlorpyriphos was evaluated for effect on germination and seedling vigour in the laboratory conditions. Field efficacy of the effective doses of the above insecticides was evaluated, together with the pre-sowing soil application of phorate and carbofuran followed by foliar application of various insecticides at flowering against pests of mungbean. The insecticidal treatments significantly reduced the population of various insect pests in both growing seasons. Grain yield varied significantly from the lowest value of 214.2 and 353.3 kg/ha in untreated control to the highest value of 583.3 and 524.6 kg/ha in treatments with phorate followed by quinalphos in summer and rainy season, respectively. Seed treatment with monocrotophos, carbosulfan, dimethoate, methyl-o-demeton, chlorpyriphos tested at 40, 40, 120, 100 and 40 g a.i./ha dosages, respectively, followed by sprays at flowering also gave higher grain yield than the untreated control.

Ahmad *et al*. (1998) conducted and experiment and reported that the applications of 0.3% Dimethoate or 0.4% Monocrotophos at 45 and 60 DAS were found effective in protecting Kharif mungbean against lepidopteran pod borers and other pests attacking the crop at the flowering and fruiting stage. Bakr (1998) reported that the pod borer can also be controlled by Cymbush 10 EC @ 1.0 ml/L 0f water.

In a field experiment for the control of stemfly (*Ophiomyia phaseoli*) of mungbean four granular insecticides (Carbofuran, Phorate, Quinalphos applied at 0.75 and 1.0 kg a.i. ha^{-1} each, and Cartap hydrochloride @ 0.75, 1.0 and 1.5 kg a.i./ha were evaluated by Dhiman *et al*. (1993). From the findings they observed that all of the tested granular insecticides were found to be more effective for controlling mungbean stemfly than the control condition.

Raj and Kalra (1995) observed the succession and abundance of insect pests on *Vigna radiata* and *V. mungo* in Hisar, India, during summer. These crops were attacked by 22 and 16 insect pest species, respectively, at different stages of growth. The most important insect pests were *Empoasca kerri*, *Ophiomyia phaseoli*, *Austroagallia* sp., *Bemisia tabaci* and *Nysius* sp. The peak populations of *E. kerri* (nymphs and adults), *O. phaseoli*, *Austroagallia* sp., *B. tabaci* and

Nysius sp. (adults) was 6.40, 0.25, 10.82, 16.65 and 5.60 per plant on *V. radiata*, while 9.25, 0.75, 7.67, 19.25 and 4.05 insects per plant on *V. mungo*, respectively.

Ashfaq *et al*. (1995) investigated the role of antagonistic microbes like *Arachniotus* sp. and *Trichoderma harzianum* along with other major inputs per recommendations of the Agriculture Department, Faisalabad, Pakistan and found that mungbean (*Vigna radiata*) suffers heavily due to attack of various pest insects and so far emphasis has been on the control of these insect pests with chemical insecticides. The results of the investigations showed that the combined treatments of Tamaron 600 SL [methamidophos], Aspergopak (*Arachniotus* sp.), Trichopak (*T. harzianum*) and hoeing gave the highest yield (2.41 kg) and minimum black thrips population (1.80 thrips $leaf^{-1}$).

In a pot trial Rana and Dalal (1995) were applied *P. lilacinus* at 1 or 2 g/kg soil together with seed treatments with carbosulfan at 0.5% w/w to *Vigna radiata* for control of *H. cajanus*. All treatments receiving combined applications of nematicide and fungus had significantly lower *H. cajani* populations and significantly higher growth and yield compared to controls.

Rahman (1989) evaluated the different indices for developing an insecticide application schedule against *Euchry sopscnejus* in mungbean and Fenitrothion @ 0.1% when egg number reached about 5.2 per meter was found as the best schedule for it. In another trial was conducted by Rahman (1989) on need based application of insecticides against the pod borer in mungbean at Joydebpur and it was found that the spraying of Fenitrothion 0.1% at the flowering stage and the second spray either at an interval of 15 days or at podding offered the highest cost-benefit ratio.

Babu (1988) reported that chemical control is one of the widely practiced methods of controlling insect pests. Modern insecticides are both effective and reliable and almost all the countries of the world are relying to them more and more for the solution of insect problem. But their excessive and indiscriminate use has resulted in the development of insecticide resistance against the pests and causing environmental pollution.

Ahmad (1987) reported that pre sowing soil application of Carbofuran or Furadan 3 G, Aldicarb 10 G or Phroate 10 G 1 kg a.i./ha gave significant control of stemfly damage and two applications of Dimethoate or Monocrotophos at 45 and 60 DAS gave effective control of pod borer damage. Rahman (1987) also observed that Fenitrothion or Sumithion 50 EC @ 2ml/L of water was recommended for the control of pod borer.

Srivastava *et al*. (1987) reported that the synthetic pyrethroids were effective in reducing pod borer damage and did not leave a toxic residue in field condition. Lal (1987) reported that foliar application at flower initiation with Endosulfon 0.07%, Dimethoate 0.03%, Phosphamidon 0.03% gave significant control of pod damage against pod borer.

Chhabra and Kooner (1985) reported that Cypermethrin (Cymbush) 0.006 was highly effective against galerucid beetle, while Dimethoate 0.03 percent against jassid. They also reported that treatments with Aldicarb and Monocrotophos, Dimethoate, Malathion or Endosulfan gave significant control of thrips. For the control of hairy caterpillar of mungbean Diazinon 60 EC or Nuvacron 40 WSC @ 1.5 ml per liter of water can be used. Jassid may be controlled by a basal application of a systemic insecticide at the time of sowing, followed by a foliar spray (Catipon, 1986). Gupta and Singh (1984) obtained the largest increase in grain yield by controlling stemfly with Aldicarb and Disulfoton.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to study the incidence of major insect pests of blackgram and their management. The materials and methods for this experiment includes a short description of the location of experimental site, soil and climatic conditions of the experimental area, materials used for the experiment, design of the experiment, data collection and data analysis procedure. The details description of the materials and methods for this experiment have been presented below under the following headings-

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from March to May, 2016.

3.1.2 Experimental location

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka and it was located in 24.09^0N latitude and 90.26^0E longitudes. As per the Bangladesh Meteorological Department, Agargaon, Dhaka-1207 the altitude of the location was 8 m from the sea level.

3.1.3 Characteristics of soil

The general soil type of the experimental field is Shallow Red Brown Terrace soil and the soil belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28). A composite sample of the experimental field was made by collecting soil from several spots of the field at a depth of 0-15 cm before initiation of the experiment. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay loam with pH and organic matter 6.2 and 1.12%, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay, details have been presented in Appendix I.

3.1.4 Climatic conditions

The climatic condition of experimental site is subtropical and characterized by three distinct seasons, the *Rabi* from November to February and the *Kharif-I*, pre-monsoon period or hot season from March to April and the *Kharif-II* monsoon period from May to October. The monthly average temperature, relative humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix II. During the experimental period the maximum temperature (34.7^{0}C), highest relative humidity (70%) and highest rainfall (185 mm) was recorded in the month of May 2016, whereas the minimum temperature (19.6^{0}C), minimum relative humidity (65%) and no rainfall was recorded for the month of March 2016.

3.2 Experimental details

3.2.1 Treatments of the experiment

The experiment consists of the following seven (7) insect pests management practices and was applied starting from 5 days after seed germination:

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

3.2.2 Planting material

Blackgram variety BARI mash-3 (Hemantoo) was used as planting materials for the study. The seeds of BARI mash-3 were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. The yellow mosaic virus resistant this variety was released by BARI in 1996 and it was developed through hybridization between line BMA-2140 and BMA-2038.

3.2.3 Land preparation

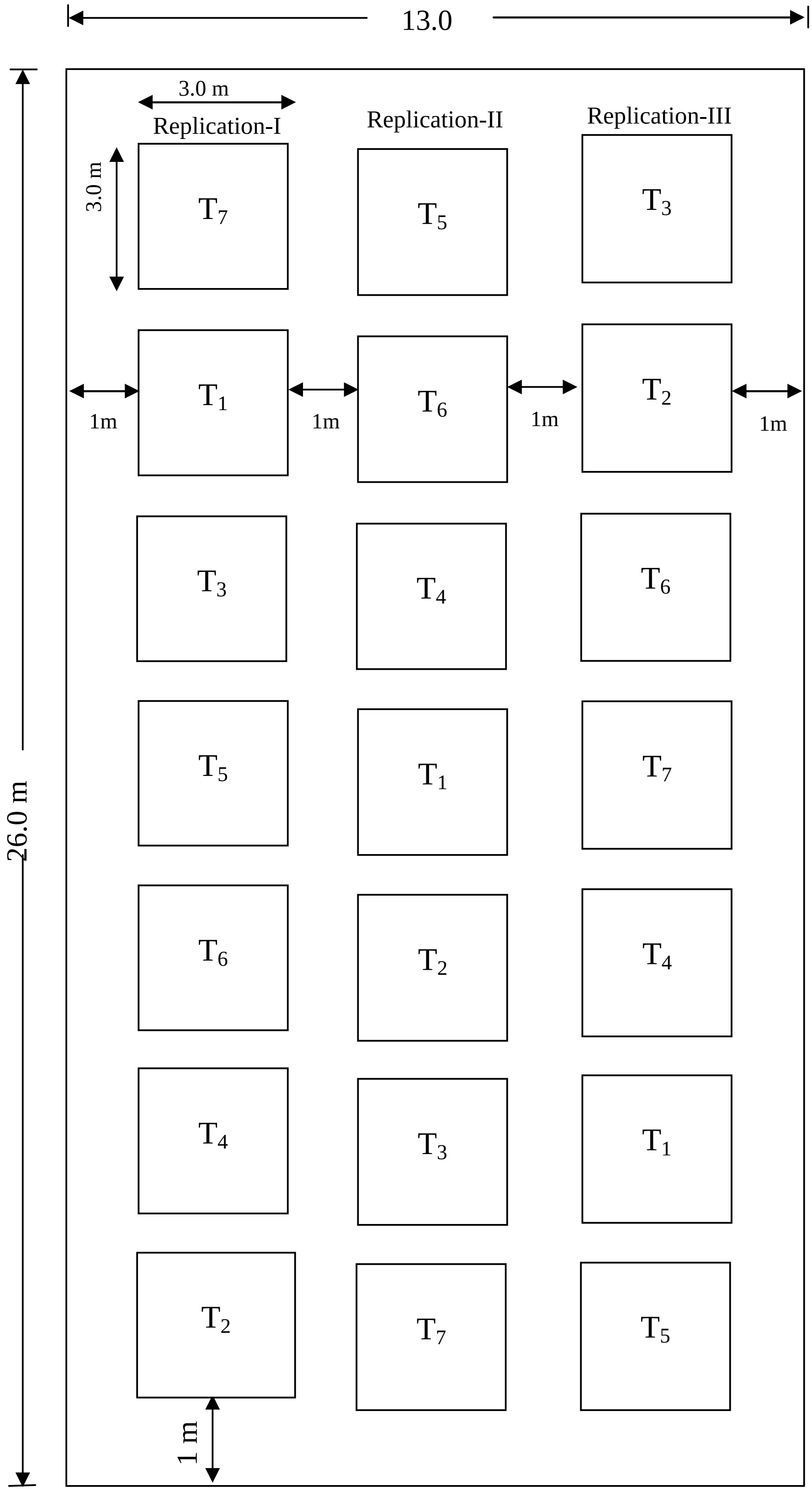
The land where the experiment was conducted was opened on the 2nd March, 2016 with the tractor drawn disc plough. Ploughed soil again and again to brought into desirable tilth by cross-ploughing, harrowing and laddering. The stubble and weeds were removed from the tilth soil. The first ploughing and the final land preparation were done on the 8th and 12th March, 2016, respectively. Experimental land was divided into unit plots following the experimental design.

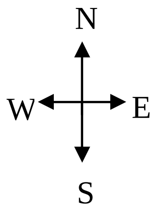
3.2.4 Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP) and gypsum were used as a source of nitrogen, phosphorous, potassium and sulphur respectively. Urea, TSP, MoP and gypsum were applied at the rate of 50, 85, 35 and 5 kg per hectare, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation. All of the fertilizers except urea were applied during final land preparation and urea was applied in two equal installments at 20 and 30 days after sowing (DAS).

3.2.5 Experimental layout and design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 26.0 m × 13.0 m was divided into three equal blocks. Each block was divided into 7 plots, where 7 treatments were allocated at random. There were 21 unit plots altogether in the experiment. The size of the each unit plot was 3.0 m × 3.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experimental plot is shown in Figure 1.





Plot size: 3.0 m × 3.0 m

Plot spacing: 50 cm

Between replication: 1.0 m

Treatments

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

Figure 1. Layout of the experimental plot

3.3 Growing of crops

3.3.1 Sowing of seeds in the field

The seeds of blackgram were sown on March 12, 2016. Before sowing seeds were treated with fungicide Bavistin to control the seed borne disease. The seeds were sown in furrows having a depth of 2-3 cm. Row to row distance was 30 cm.

3.3.2 Application of different treatments

Admire 200 SL, Voliam Flexi, Nitro 505 EC, Casper 5 SG, Dimethoate 40 EC and Neem oil 3 ml + 5 ml/L of water of trix were sprayed in assigned plots by using knapsack sprayer at 10 days interval. The spraying was always done in the afternoon to avoid bright sunlight. The spray materials were applied uniformly to obtain complete coverage of whole plants of the assigned plots in 15 days interval starting from 5 days after seed germination. Caution was taken to avoid any drift of the spray mixture to the adjacent plots at the time of the spray application. At each spray application the spray mixture was freshly prepared.

3.3.3 Intercultural operations

3.3.3.1 Thinning

Seeds started to germination of 4 Days After Sowing (DAS). Thinning was done two times; first thinning was done at 8 DAS, while second at 15 DAS to maintain optimum plant population in each plot.

3.3.3.2 Irrigation, drainage and weeding

Irrigation was provided before 15 and 30 DAS for optimizing the vegetative growth of blackgram for the all experimental plots equally. Proper drain also made for drained out excess water from irrigation and also rainfall from the experimental plot. The crop field was weeded properly and herbicides were applied as per treatment of weed control methods.

3.4 Crop sampling and data collection

Five plants from each treatment were randomly marked inside the central row of each plot with the help of sample card.

Plate 01: Experimental field during the study period

Plate 02: Healthy blackgram plant in the experimental field during the study period

Plate 03: Jute hairy caterpillars infested blackgram leaves

Plate 04: Stink bug infested blackgram leaves

3.4.1 Monitoring and data collection

The blackgram plants of different treatments were closely examined, counted and recorded at regular intervals commencing from germination to harvest. The following parameters were considered during data collection -

- Stem fly infested plant
- Stem tunneling
- Number of stem fly larvae/pupae per plant
- Number of jassid per 10 leaves
- Number of whitefly per 10 leaves
- Number of hairy caterpillar per 10 leaves
- Number of thrips per 10 flowers
- Number of healthy pods at early, mid and late stage
- Number of infested pods at early, mid and late stage
- Pod infestation (%) in number at early, mid and late stage
- Plant height (cm) at harvest
- Number of pods per plant
- Pod yield per hectare (ton)

3.4.2 Determination of pod infestation by number and infestation reduction over control

All the healthy and infested pods were counted from 5 randomly selected plants from middle rows of each plot and examined. The collected data were divided into early, mid and late pod development stage. The healthy and infested pods were counted at early, mid and late stage and the percent pod damage was calculated using the following formula:

$$\text{Pod infestation (\%)} = \frac{\text{Number of infested pods}}{\text{Total number of pods}} \times 100$$

$$\% \text{ Infestation reduction} = \frac{\text{Infestation (\%) in control} - \text{Infestation (\%) in the concerned treatment}}{\text{Infestation (\%) in control}} \times 100$$

3.4.3 Determination of stem tunneling

For determination of stem tunneling, 5 randomly selected plants from each plot were uprooted and stems were split opened by a scalpel for recording the extent of stem tunneling by stemfly. The lengths of the stem were measured by a scale. From these data, percentage of stemfly infested plants and percentage of stem tunneling were calculated. Percent stem tunneling was calculated using the following formula:

$$\text{Stem tunneling (\%)} = \frac{\text{Length of stem tunneling}}{\text{Total length of stem}} \times 100$$

3.5 Harvest and post harvest operations

The plants of middle three rows, avoiding border rows, of each plot were harvested. The pods were then threshed; cleaned and sun dried. The yield obtained from each plot was converted into yield per hectare.

3.6 Procedure of data collection

3.6.1 Plant height at harvest

The plant heights of 5 randomly selected plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in centimeter (cm). Data were recorded from the inner rows plant of each plot during harvesting period.

3.6.2 Number of pods per plant

Number of total pods of selected plants from each plot was counted and the mean number was expressed on plant^{-1} basis. Data were recorded as the average of 5 plants selected at random from the inner selected rows of each plot.

3.6.3 Fruits yield per hectare

Fruits per plot were converted into hectare and the weight of fruits per hectare was calculated and expressed in ton.

3.7 Statistical analysis

The data on different parameters as well as yield of blackgram were statistically analyzed to find out the significant differences among the effects of different treatments. The mean values of all the characters were calculated and analyses of variance were performed by the 'F' (variance ratio) test using MSTAT-C software. The significance of the differences among the mean values in respect of different parameters was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the incidence of major insect pests of blackgram and their management. The analysis of variance (ANOVA) of the data on the incidence of different insect pests on blackgram, pod infestation, different yield attributes and yield are given in Appendix III-VIII. The results have been presented by using different Table and discussed with possible interpretations under the following headings and sub headings:

4.1 Incidence of stem fly larvae/pupae per plant

Effect of different treatments on incidence of number of stem fly larvae/pupae per plant showed significant variation of blackgram (Table 1). Data revealed that the lowest number of stem fly larvae/pupae per plant (0.33) was found from T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval), T_3 (Nitro 50 SEC (Chloropyifor + Cupsmethral at 10 days interval) @ 2.0 ml/L of water) and T_5 (Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval) treatment which was statistically similar (1.00) to T_2 (Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval) and closely followed (1.33 and 1.67) by T_6 (Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval) and T_4 (Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval) treatment, while the highest number of stem fly larvae/pupae per plant (4.67) was observed from T_7 (untreated control) treatment. In case of reduction on number of stem fly larvae/pupae per plant over control, the highest (92.93%) was recorded for the treatment T_1, T_3 and T_5, whereas the lowest (64.24%) from T_4 treatment. From the findings it is revealed T_1, T_3 and T_5 was more effective among the treatments in terms of controlling stem fly larvae/pupae in blackgram followed by T_2. Chemical control play a significant role for stem fly control as described by Chhabra and Kooner, 1985; Dhiman *et al*. (1993).

Table 1. Effect of different treatments on the incidence of stem fly larvae/pupae attacking on blackgram

Treatments	Number of stem fly larvae/pupae per plant	Stem fly population reduction over control (%)
T_1	0.33 c	92.93
T_2	1.00 bc	78.59
T_3	0.33 c	92.93
T_4	1.67 b	64.24
T_5	0.33 c	92.93
T_6	1.33 b	71.52
T_7	4.67 a	--
$LSD_{(0.05)}$	0.736	--
CV(%)	9.11	--

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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

4.2 Intensity of stem fly infestation

Statistically significant variation was recorded for intensity of stem fly infested blackgram due to different treatments (Table 2). It was observed that the lowest stem fly infestation (1.05%) was found from T_3 (Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval) followed (1.88%) by T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval), whereas the highest stem fly infestation (7.22%) was observed from T_7 (untreated control) followed (3.95% and 3.61%) by T_6 (Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval) and T_4 (Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval) treatments and they were statistically similar. In case reduction on stem fly infestation over control, the highest (85.46%) was recorded for the treatment T_3 and the lowest (45.29%) from T_6 treatment. From the findings it is revealed that T_3 was more effective for controlling stem fly infestation followed by T_1. Dhiman *et al*. (1993) reported that all of the tested granular insecticides were found to be more effective for controlling blackgram stem fly than the control condition. Rahman (1991) reported from earlier study that in blackgram; upto 97% plants were found to be infested by stem fly which was much higher than the findings of this study.

4.3 Stem tunneling

Stem tunneling of blackgram showed statistically significant differences due to different treatments (Table 2). Data revealed that the lowest stem tunneling (2.66%) was observed from T_3 (Nitro 50 SEC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water) which was statistically similar (3.28% and 3.44%) with T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval) and T_2 (Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval) treatment. Conversely, the highest stem tunneling (12.25%) was observed from T_7 (untreated control) treatment. In case of reduction on stem tunneling over control, the highest reduction (78.29%) was recorded for the treatment T_3 but the lowest (64.57%) from T_5 treatment.

Table 2. Effect of different treatments on the incidence and damage severity of stem fly by infesting plant and stem tunneling of blackgram

Treatments	Stem fly infested plant (%)	Stem tunneling (%)	Reduction on infestation over control (%)	
			Stem fly infested plant	Stem tunneling
T_1	1.88 e	3.28 cd	73.96	73.22
T_2	3.00 c	3.44 bcd	58.45	71.92
T_3	1.05 f	2.66 d	85.46	78.29
T_4	3.61 b	4.08 bc	50.00	66.69
T_5	2.56 d	4.34 b	64.54	64.57
T_6	3.95 b	3.85 bc	45.29	68.57
T_7	7.22 a	12.25 a	--	--
$LSD_{(0.05)}$	0.377	0.877	--	--
CV(%)	6.93	10.68	--	--

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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

4.4 Incidence of jassid

Significant variation was recorded for number of jassid per 10 leaves of blackgram due to different treatments (Table 3). Among the treatments the lowest number of jassid per 10 leaves (1.22) was found from T_3 (Nitro 50 SEC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water) followed (1.95) by T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval) treatment, whereas the highest number of jassid per 10 leaves (9.39) was observed from T_7 (untreated control) followed (4.02) by T_4 (Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval). In case reduction on number of jassid per 10 leaves over control, the highest reduction (87.01%) was recorded from the treatment T_3 but the lowest (57.19%) from T_4 treatment. From the findings it is revealed Nitro 50 SEC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water was more effective among the management practices in terms of controlling jassid. Rahman (1989) reported 43.4% infestation by jassids and it may be controlled by application of systemic insecticide at the time of sowing by foliar spray.

4.5 Incidence of whitefly

Significant variation was recorded of number of whitefly per 10 leaves of blackgram for different insect pest management practices (Table 3). Data revealed that the lowest number of whitefly per 10 leaves (1.19) was found from T_3 (Nitro 50 SEC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water) which was statistically similar (1.65) with T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval), while the highest number of whitefly per 10 leaves (7.77) was observed from T_7 (untreated control). In case reduction on number of whitefly per 10 leaves over control, the highest (87.01%) was recorded for the treatment T_3 treatment and the lowest (57.19%) from T_4 treatment. From the findings it is revealed that Nitro 50 EC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water was more effective among the treatments in terms of controlling whitefly in blackgram followed by Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval.

Table 3. Effect of different treatments on the incidence of jassid and whitefly on blackgram

Treatments	Number of jassid per 10 leaves	Number of whitefly per 10 leaves	Population reduction over control (%)	
			Jassid	Whitefly
T_1	1.95 e	1.65 fg	79.23	78.76
T_2	3.16 cd	2.41 de	66.35	68.98
T_3	1.22 f	1.19 g	87.01	84.68
T_4	4.02 b	3.21 bc	57.19	58.69
T_5	2.82 d	1.95 ef	69.97	74.90
T_6	3.52 c	2.77 cd	62.51	64.35
T_7	9.39 a	7.77 a	--	--
$LSD_{(0.05)}$	0.384	0.576	**--**	**--**
CV(%)	6.18	5.67	**--**	**--**

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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

4.6 Incidence of jute hairy caterpillar

Statistically significant variations were recorded of number of jute hairy caterpillar per plant of blackgram due to different treatments (Table 4). Data revealed that the lowest number of jute hairy caterpillar per plant (1.07) was found from T_4 (Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval) which was followed (1.53, 1.60 and 1.67) by T_3 (Nitro 50 SEC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water), T_2 (Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval) and T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval) but the highest number of jute hairy caterpillar per plant (3.87) was found from T_7 (untreated control) treatment. In case reduction on number of jute hairy caterpillar per plant over control, the highest reduction (72.35%) was recorded from treatment T_4 and the lowest (48.32%) from T_6 treatment. From the findings it is revealed Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval was more effective among the management practices in terms of controlling jute hairy caterpillar.

4.7 Incidence of stink bug

Statistically significant variation was recorded of number of stink bugs per 10 leaves of blackgram due to different treatments (Table 4). The lowest number of stink bugs per 10 leaves (1.27) was found from T_4 (Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval) treatment which was statistically similar (1.53) to T_5 (Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval). Contrary, the highest number of stink bugs per 10 leaves (5.27) was observed from T_7 (untreated control) treatment. In case reduction on number of stink bugs per 10 leaves over control, the highest reduction (75.90%) was recorded for the treatment T_4, while the lowest (44.40%) from T_6 treatment. From the findings it is revealed Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval was more effective in controlling stink bugs in blackgram. Chhabra and Kooner (1985) have reported extensive damage to the summer blackgram due to stink bugs.

Table 4. Effect of different treatments on the incidence of hairy caterpillar and stink bug attacking on blackgram

Treatments	Number of jute hairy caterpillars per plant	Number of stink bugs per 10 leaves	Population reduction over control (%)	
			Jute hairy caterpillar	Stink bug
T_1	1.67 bc	2.67 b	56.85	49.34
T_2	1.60 bc	2.53 b	58.66	51.99
T_3	1.53 c	2.40 b	60.47	54.46
T_4	1.07 d	1.27 c	72.35	75.90
T_5	1.33 cd	1.53 c	65.63	70.97
T_6	2.00 b	2.93 b	48.32	44.40
T_7	3.87 a	5.27 a	--	--
$LSD_{(0.05)}$	0.394	0.503	--	--
CV(%)	11.85	10.65	--	--

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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

4.8 Pod bearing status at early pod development stage

Number of healthy pods, infested pods and percent infestation of blackgram pod showed statistically significant differences at early pod development stage for different treatments (Table 5). The highest number of healthy pods plant^{-1} (28.90) was recorded in T_2 (Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval) treatment which was statistically identical (28.90 and 26.10) with T_3 (Nitro 50 SEC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water) and T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval), respectively and followed (23.70) by T_6 (Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval). On the other hand, the lowest number of healthy pods plant^{-1} (20.50) was recorded in T_7 (untreated control) treatment which was statistically similar (20.70 and 22.10) with T_4 (Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval) and T_5 (Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval). The lowest number of infested pods plant^{-1} (0.63) was recorded in T_2 treatment which was statistically similar (0.83) to T_3 and followed by other treatment except T_7, while the highest number (2.80) was recorded in T_7 treatment. The lowest percent of infested pods plant^{-1} in number (2.16%) was recorded in T_2 treatment which was statistically similar (3.02%) by T_3 and followed (4.28%) by T_1 treatment, whereas the highest infestation percent in number (12.04) was recorded in T_7 treatment (untreated control). Blackgram pod infestation percentage reduction over control at early pod stage in number was estimated for different management practices and the highest reduction (82.06) was recorded for the treatment T_2 and the lowest (47.43) from T_4 treatment. From the findings it is revealed that Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval performed maximum healthy pods and minimum infested pods as well as the lowest percent of pod infestation in number. While in untreated control treatment gave the minimum healthy pods, maximum infested pods and the highest percentage of infestation under the trail.

Table 5. Effect of different treatments on the damage severity of pod borer attacking blackgram at early pod development stage

Treatments	Healthy pods/plant (No.)	Infested pods/plant (No.)	Infestation (%)	Reduction of infestation over control (%)
T_1	26.10 ab	1.17 b	4.28 c	64.45
T_2	28.90 a	0.63 c	2.16 d	82.06
T_3	27.30 a	0.83 c	3.02 d	74.92
T_4	20.70 c	1.40 b	6.33 b	47.43
T_5	22.10 c	1.33 b	5.69 b	52.74
T_6	23.70 bc	1.40 b	5.58 b	53.65
T_7	20.50 c	2.80 a	12.04 a	--
$LSD_{(0.05)}$	3.431	0.239	1.179	--
CV(%)	7.97	9.71	11.87	--

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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

4.9 Pod bearing status at mid pod development stage

Number of healthy pods, infested pods and percent infestation of blackgram pod showed statistically significant differences at mid pod development stage for different treatments (Table 6). The highest number of healthy pods plant^{-1} (44.10) was recorded in T_2 (Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval) treatment which was statistically identical (39.83 and 38.90) with T_3 (Nitro 50 SEC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water) and T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval), respectively and followed (37.13) by T_6 (Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval). On the other hand, the lowest number of healthy pods plant^{-1} (26.50) was recorded in T_7 (untreated control) treatment which was statistically similar (28.80 and 29.07) with T_4 (Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval) and T_5 (Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval). The lowest number of infested pods plant^{-1} (1.40) was recorded in T_2 treatment which was statistically similar (1.63) to T_3 and closely followed (2.00) by T_1 treatment, while the highest number (4.20) was recorded in T_7 treatment. The lowest percent of infested pods plant^{-1} in number (3.09%) was recorded in T_2 treatment which was statistically similar (4.02%) by T_3 and followed (4.88%) by T_1 treatment, whereas the highest infestation percent in number (13.69%) was recorded in T_7 treatment (untreated control). Blackgram pod infestation percentage reduction over control at mid pod development stage, the highest reduction (77.43) was recorded for the treatment T_2 and the lowest (39.37) from T_4 treatment. From the findings it is revealed that Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval performed maximum healthy pods and minimum infested pods and lowest pod infestation, while in untreated control treatment gave the minimum percentage of infestation under the trail. Lal (1987) reported that the foliar application at flower initiation stage with Endosulfon 0.07%, Dimethoate 0.03%, Phosphamidon 0.03% gave significant control of pod damage against pod borer.

Table 6. Effect of different treatments on the damage severity of pod borer attacking blackgram at mid pod development stage

Treatments	Healthy pods/plant (No.)	Infested pods/plant (No.)	Infestation (%)	Reduction of infestation over control (%)
T_1	38.90 ab	2.00 cd	4.88 de	64.35
T_2	44.10 a	1.40 e	3.09 f	77.43
T_3	39.83 ab	1.63 de	4.02 ef	70.64
T_4	28.80 c	2.60 b	8.30 b	39.37
T_5	29.07 c	2.33 bc	7.45 bc	45.58
T_6	37.13 b	2.53 b	6.43 cd	53.03
T_7	26.50 c	4.20 a	13.69 a	--
$LSD_{(0.05)}$	5.949	0.464	1.576	--
CV(%)	9.58	10.92	12.96	--

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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

4.10 Pod bearing status at late pod development stage

Number of healthy pods, infested pods and percent infestation of blackgram pod showed statistically significant differences at late pod development stage for different insect pests management practices (Table 7). The highest number of healthy pods plant^{-1} (54.90) was recorded in T_2 (Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval) treatment which was statistically similar (49.40) with T_3 (Nitro 50 SEC (Chloropyifor + Cupsmethral) @ 2.0 ml/L of water) and closely followed (46.03 and 44.77) by T_1 (Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval) and T_6 (Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval). On the other hand, the lowest number (37.17) was recorded in T_7 (untreated control) treatment which was statistically similar (38.83 and 41.80) with T_4 (Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval) and T_5 (Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval). The lowest number of infested pods plant^{-1} (2.27) was recorded in T_2 treatment which was statistically similar (2.63) to T_3 and closely followed (3.00) by T_1 treatment, while the highest number (6.40) was recorded in T_7 treatment. The lowest percent of infested pods plant^{-1} in number (3.96%) was recorded in T_2 treatment which was followed (5.09% and 6.08%) by T_3 and T_1 treatment, whereas the highest infestation percent in number (14.70%) was recorded in T_7 treatment (untreated control). Blackgram pod infestation percentage reduction over control at late pod development stage, the highest value (73.06) was recorded for the treatment T_2 treatment and the lowest value (37.82) was found from T_4 treatment. From the findings it is revealed that Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval performed maximum healthy pods and minimum infested pods and lowest pod infestation, while in untreated control treatment gave the highest percentage of infested pod under the trail. Lal (1987) reported that the foliar application at flower initiation stage with Endosulfon 0.07%, Dimethoate 0.03%, Phosphamidon 0.03% gave significant control of pod damage against pod borer in blackgram plant.

Table 7. Effect of different treatments on the damage severity of pod borer attacking blackgram at late pod development stage

Treatments	Healthy pods/plant (No.)	Infested pods/plant (No.)	% Infestation	Reduction of infestation over control (%)
T_1	46.03 bc	3.00 cd	6.08 d	58.64
T_2	54.90 a	2.27 e	3.96 e	73.06
T_3	49.40 ab	2.63 de	5.09 d	65.37
T_4	38.83 de	3.90 b	9.14 b	37.82
T_5	41.80 cde	3.67 b	8.08 bc	45.03
T_6	44.77 bcd	3.47 bc	7.23 c	50.82
T_7	37.17 e	6.40 a	14.70 a	--
$LSD_{(0.05)}$	6.233	0.616	1.101	--
CV(%)	7.84	9.56	7.99	--

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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

4.11 Yield attributes and yield

4.11.1 Plant height at harvest

Statistically significant variation was recorded in terms of plant height of blackgram at harvest of incidence of inset pests by using different treatments (Table 8). Data revealed that the longest plant (77.96 cm) was found in T_3 treatment which was statistically identical (74.89 cm, 72.35 cm and 70.91 cm) with T_1, T_5 and T_2 treatment, respectively and closely followed (68.74 cm and 67.82 cm) by T_6 and T_4, while the shortest plant (65.32 cm) was recorded in T_7 treatment. Plant height increase over control was estimated for different treatments and the highest value (19.35%) was observed for the treatment T_3 but the lowest value (3.83%) was found from T_4 treatment.

4.11.2 Number of pods per plant

Number of pods per plant of blackgram at harvest showed statistically significant differences on incidence of inset pests by using different treatments (Table 8). The maximum number of pods/plant (54.10) was found in T_3 treatment which was statistically similar (52.19) with T_1 and closely followed (49.18) by T_2, while the minimum number (42.84) was observed in T_7 treatment. Number of pods per plant increase over control the highest (26.28%) was recorded for the treatment T_3, while the lowest (3.06%) from T_4 treatment.

4.11.3 Yield per hectare

Yield per hectare of blackgram showed statistically significant differences for controlling incidence of inset pests by using different treatments (Table 8). The highest yield per hectare (1.75 ton) was observed in T_4 treatment which was statistically similar (1.66 ton and 1.61 ton) with T_1, T_2 and T_4, respectively and closely followed (1.58 ton and 1.50 ton) by T_5 and T_6, whereas the lowest yield per hectare (1.18 ton) was found in T_7 treatment. Yield per hectare of blackgram increase over control was the highest (48.31%) was recorded from T_4 and the lowest (27.12%) from T_1 treatment.

Table 8. Effect of different treatments on plant height, number of pods/plant and yield per hectare of blackgram

Treatments	Plant height (cm)	Number of pods/plant	Yield (t/ha)	Increase over control (%)		
				Plant height	Number of pods/plant	Yield (t/ha)
T_1	74.89 ab	52.19 ab	1.66 ab	14.65	21.83	40.68
T_2	70.91 abc	49.18 bc	1.61 abc	8.56	14.80	36.44
T_3	77.96 a	54.10 a	1.75 a	19.35	26.28	48.31
T_4	67.82 bc	44.15 de	1.61 abc	3.83	3.06	36.44
T_5	72.35 abc	47.90 cd	1.58 bc	10.76	11.81	33.90
T_6	68.74 bc	46.18 cde	1.50 bc	5.24	7.80	27.12
T_7	65.32 c	42.84 e	1.18 c	--	--	--
$LSD_{(0.05)}$	6.868	3.657	0.147	--	--	--
CV(%)	6.54	5.19	6.32	--	--	--

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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

4.12 Economic analysis

The analysis was done in order to find out the most profitable treatments based on cost and benefit of various components. The results of economic analysis of blackgram cultivation showed that the highest net benefit of Tk. 225,800 ha^{-1} was obtained in T_3 treatment and the second highest was found Tk. 214,440 ha^{-1} in T_1 (Table 9). The highest benefit cost ratio (2.13) was estimated for T_3 treatment and the lowest (1.45) for T_5 treatment under the trial. The highest BCR was found in the treatment T_3 may be due to the minimum pest infestation to the other treatment components and the highest yield of this treatment. Rahman (1989) spraying of Fenitrothion 0.1% at the flowering stage and the second spray either at an interval of 15 days or at podding offered the highest cost-benefit ratio.

Table 9. Benefit cost ratio for the production of blackgram due to different treatments

Treatments	Cost of pest Management (Tk.)	Yield (t/ha)	Gross return (Tk.)	Net return (Tk.)	Adjusted net return (Tk.)	Benefit cost ratio
T_1	24600	1.66	239040	214440	44520	1.81
T_2	23400	1.61	231840	208440	38520	1.65
T_3	26200	1.75	252000	225800	55880	2.13
T_4	25700	1.61	231840	206140	36220	1.41
T_5	23500	1.58	227520	204020	34100	1.45
T_6	18500	1.50	216000	197500	27580	1.49
T_7	0	1.18	169920	169920	0	

Price of blackgram @ Tk. 120/kg

T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval

T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval

T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval

T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval

T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval

T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval

T_7: Untreated control

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from March to May, 2016 at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka to study the incidence of major insect pests of blackgram and their management. Blackgram variety BARI mash-3 (Hemantoo) was used as planting materials for the study. The experimental treatments of different insect pests management practices was T_1: Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval; T_2: Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval; T_3: Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval; T_4: Casper 5 SG (Emamectin Benzoate) @ 1 gm/L of water at 10 days interval; T_5: Dimethoate 40 EC (Rogor 40 L) @ 2 ml/L of water at 10 days interval; T_6: Neem oil @ 3 ml + Trix @ 5 ml/L of water at 10 days interval and T_7: Untreated control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data was recorded on the incidence of different insect pests on blackgram, pod infestation, different yield attributes and yield due to different treatment.

The lowest number of stem fly larvae/pupae per plant (0.33) was found from T_1, while the highest (4.67) was observed from T_7. In case treatments effects of stem fly larvae/pupae per plant over control, the highest reduction (92.93%) was recorded for the treatment T_1, T_3 and T_5, whereas the lowest (64.24%) from T_4 treatment. The lowest stem fly infestation (1.05%) was found from T_3, whereas the highest (7.22%) was observed from T_7 In case reduction on stem fly infestation over control, the highest value (85.46%) was recorded for the treatment T_3 and the lowest value (45.29%) from T_6 treatment. The lowest stem tunneling (2.66%) was observed from T_3, while the highest stem tunneling (12.25%) was observed from T_7. In case reduction on stem tunneling over control, the highest value (78.29%) was recorded for the treatment T_3 and the lowest value (64.57%) from T_5 treatment. The lowest number of jassid per 10 leaves (1.22) was found from T_3, whereas the highest number of jassid per 10 leaves (9.39) was observed from T_7. In case reduction on number of jassid per 10 leaves over control, the highest reduction (87.01%) was recorded from T_3 treatment but the lowest (57.19%) from T_4 treatment. The lowest number of whitefly per 10 leaves (1.19) was found from T_3, while the highest (7.77) was observed from T_7. In case reduction on number of whitefly per 10 leaves over control, the highest value (87.01%) was recorded on T_3 treatment and the lowest value (57.19%) from T_4 treatment. The lowest number of jute hairy caterpillar per plant (1.07) was found from T_4, while the highest (3.87) from T_7. In case reduction on number of jute hairy caterpillar per plant over control, the highest reduction (72.35%) was recorded for treatment T_4, while the lowest value (48.32%) from T_6 treatment. The lowest number of stink bugs per 10 leaves (1.27) was found from T_4, while the highest (5.27) was observed from T_7. In case reduction on number of stink bugs per 10 leaves over control, the highest value (75.90%) was recorded for the treatment T_4 but the lowest value (44.40%) from T_6 treatment.

At early development stage, the highest number of healthy pods plant^{-1} (28.90) was recorded in T_2 treatment but the lowest (20.50) in T_7 treatment. The lowest number of infested pods plant^{-1} (0.63) was recorded in T_2 treatment, while the highest (2.80) in T_7 treatment. The lowest percent of infested pods plant^{-1} in number (2.16%) was recorded in T_2 treatment, whereas the highest (12.04%) was recorded in T_7 treatment. Blackgram pod infestation percentage reduction over control at early pod stage in number the highest reduction (82.06%) was recorded in T_2 treatment and the lowest (47.43%) from T_4 treatment. At mid pod development stage, the highest number of healthy pods plant^{-1} (44.10) was recorded in T_2 but the lowest (26.50) in T_7 The lowest number of infested pods plant^{-1} (1.40) was recorded in T_2 treatment, while the highest (4.20) in T_7 treatment. The lowest percent of infested pods plant^{-1} in number (3.09%) was recorded in T_2 treatment. Conversely, the highest infestation percent in number (13.69%) was recorded in T_7 treatment. Blackgram pod infestation percentage reduction over control at mid pod development stage, the highest value (77.43%)

was recorded from T_2 treatment and the lowest value (39.37%) from T_4 treatment. At late development stage, the highest number of healthy pods plant^{-1} (54.90) was recorded in $T_{2,}$ while the lowest number (37.17) in T_7 treatment. The lowest number of infested pods plant^{-1} (2.27) was recorded in T_2 treatment, while the highest number (6.40) in T_7 treatment. The lowest percent of infested pods plant^{-1} in number (3.96%) was recorded in T_2 treatment, whereas the highest (14.70%) in T_7 treatment. Blackgram pod infestation percentage reduction over control at late pod development stage, the highest value (73.06%) for the treatment T_2 and the lowest value (37.82%) from T_4 treatment.

The longest plant (77.96 cm) was recorded in T_3 treatment, while the shortest plant (65.32 cm) in T_7 treatment. Plant height increase over control the highest (19.35%) was recorded for the treatment T_3 and the lowest (3.83%) from T_4 treatment. The maximum number of pods/plant (54.10) was recorded in T_3 treatment, while the minimum (42.84) in T_7 treatment. Number of pods per plant increase over control the highest (26.28%) was recorded from treatment T_3, while the lowest (3.06%) from T_4 treatment. The highest yield per hectare (1.75 ton) was recorded in T_4 treatment, whereas the lowest (1.18 ton) in T_7 treatment. Yield per hectare of blackgram increase over control the highest (48.31%) was recorded from T_4 and the lowest (27.12%) from T_1 treatment. The results of economic analysis of blackgram cultivation showed that the highest net benefit of Tk. 225,800 ha^{-1} was obtained in T_3 treatment. The highest benefit cost ratio (2.13) was estimated for T_3 treatment and the lowest (1.45) for T_5 treatment.

Conclusion

From the above findings it was revealed that Nitro 505 EC (Chlorpyrifos + Cypermethrin) @ 2.0 ml/L of water at 10 days interval was more effective among the treatments for controlling insect pest of blackgram followed by Admire 200 SL (Imidacloprid) @ 0.5 ml/L of water at 10 days interval and Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 1 ml/L of water at 10 days interval.

Recommendations

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

1. Such study needs to be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
2. Using other chemicals with different concentrations and also bio-chemicals may be used for further study.
3. Integrated pest management practices may be introduced for effective control of blackgram insect pests.

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APPENDICES

Appendix I. Physical characteristics of field soil analyzed in Soil Resources Development Institute (SRDI) laboratory, Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
AEZ	Madhupur Tract (28)
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
Sand (%)	27
Silt (%)	43
Clay (%)	30
Textural class	Silty Clay Loam
pH	6.2
Organic matter (%)	1.12
Total N (%)	0.06
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI)

Appendix II. Monthly recorded of air temperature, relative humidity and rainfall of the experimental site during the period from March to May 2016

Month (2016)	*Air temperature (ºc)		*Relative humidity (%)	*Total rainfall (mm)
	Maximum	Minimum		
March	31.4	19.6	65	0
April	34.2	23.4	61	112
May	34.7	25.9	70	185

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1207

Appendix III. Analysis of variance of the data on number of stemfly larvae/pupae per plant, stemfly infested plant, stem tunneling of blackgram as influenced by different treatments

Source of variation	Degrees of freedom	Mean square		
		Number of stemfly larvae/pupae per plant	Stemfly infested plant (%)	Stem tunneling (%)
Replication	2	0.052	0.087	0.069
Treatment	6	1.637**	0.995**	5.108**
Error	12	0.171	0.045	0.243

**: Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on incidence of jassid, whitefly, hairy caterpillar and stink bug attacking on blackgram as influenced by different treatments

Source of variation	Degrees of freedom	Mean square			
		Number of jassid per 10 leaves	Number of whitefly per 10 leaves	Number of jute hairy caterpillars per plant	Number of stink bugs per 10 leaves
Replication	2	0.030	0.275	0.063	0.014
Treatment	6	0.123**	0.234**	0.173**	0.184**
Error	12	0.046	0.062	0.048	0.059

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on damage severity of pod borer attacking blackgram at early pod development stage as influenced by different treatments

Source of variation	Degrees of freedom	Mean square		
		Early pod development stage		
		Healthy pods/plant (No.)	Infested pods/plant (No.)	% Infestation
Replication	2	0.567	1.341	0.003
Treatment	6	14.234**	1.234**	0.156**
Error	12	3.720	0.228	0.007

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on damage severity of pod borer attacking blackgram at mid pod development stage as influenced by different treatments

Source of variation	Degrees of freedom	Mean square		
		Mid pod development stage		
		Healthy pods/plant (No.)	Infested pods/plant (No.)	% Infestation
Replication	2	0.694	0.068	0.027
Treatment	6	18.649**	1.131**	0.419**
Error	12	2.212	0.090	0.096

**: Significant at 0.01 level of probability

Appendix VII. Analysis of variance of the data on damage severity of pod borer attacking blackgram at late pod development stage as influenced by different treatments

Source of variation	Degrees of freedom	Mean square		
		Late pod development stage		
		Healthy pods/plant (No.)	Infested pods/plant (No.)	% Infestation
Replication	2	4.307	0.113	0.013
Treatment	6	17.885**	4.660**	0.562**
Error	12	2.837	0.919	0.067

**: Significant at 0.01 level of probability

Appendix VIII. Analysis of variance of the data on plant height, number of pods/plant and yield per hectare as influenced by different treatments

Source of variation	Degrees of freedom	Mean square		
		Plant height (cm)	Number of pods/plant	Yield (t/ha)
Replication	2	3.891	2.123	0.443
Treatment	6	74.254*	16.982*	0.253**
Error	12	14.91	8.234	0.063

**: Significant at 0.01 level of probability, *: Significant at 0.05 level of probability