# BIORATIONAL MANAGEMENT OF MAJOR INSECT PESTS OF BLACKGRAM

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# BIORATIONAL MANAGEMENT OF MAJOR INSECT PESTS OF BLACKGRAM

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## ***CERTIFICATE***

This is to certify that the thesis entitled, "***Biorational Management of Major Insect Pests of Blackgram***" submitted to the Faculty ofAgriculture, 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 **FARHANA HOSSAIN Registration No.18-09126** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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**DEDICATED TO**

**MY BELOVED PARENTS**

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## ABSTRACT

A field experiment was guided by RCBD trial with three replications during the period from September to November, 2019 at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka to study the biorational management of major insect pests of blackgram. Blackgram variety BARI mash-3 (*Hemantoo*) was used as planting materials for the study. The experiment consists of seven treatments as $T_1$= spinosad @0.5 ml/l of water at 10 days interval, $T_2$=emamectin benzoate @1.0 ml/l of water at 10 days interval, $T_3$= lufeneuron @0.2 g/l of water at 10 days interval, $T_4$= matrine @1 ml/l of water at 10 days interval at, $T_5$= thiamethoxam @0.5g /l of water at 10 days interval, $T_6$= neem seed kernel @5 g/l of water at 10 days interval & $T_7$= Untreated control. Major insect pests found were aphid, white fly, stemfly, stink bug, jassid, flea beetle and pod borer. The lowest number of aphid per plant (3.30) was found from $T_1$, while the highest (16.53) from $T_7$. The lowest number of whitefly per 10 leaves (4.03) was found from $T_5$, whereas the highest (13.60) from $T_7$. The lowest number of stemfly infestation per plant (2.10) was found from $T_1$, while the highest (7.70) from $T_7$. The lowest number of stink bug per plant (1.10) was found from $T_1$, while the highest (4.33) from $T_7$. The lowest number of jassid per 10 leaves (1.07) was found from $T_1$, while the highest (4.33) from $T_7$. The lowest number of flea beetle per plant (2.30) was found from $T_1$, while the highest (9.40) from $T_7$. The lowest number of flea beetle infested leaf (2.00) was found from $T_1$, while the highest (9.90) from $T_7$. At early pod development stage, the lowest infestation (2.59%) was recorded in $T_1$ treatment, whereas the highest infestation (15.60%) in $T_7$ treatment. At late pod development stage, the lowest infestation (3.31%) was recorded in $T_1$ treatment but the highest (14.19%) in $T_7$ treatment. The highest yield (1.84 ton/ha) was recorded in $T_1$ treatment, whereas the lowest (1.16 ton/ha) in $T_7$ treatment. The highest benefit cost ratio (2.31) was estimated for $T_1$ treatment, while the lowest (1.28) from $T_4$ treatment. Neem seed kernel @5 g/l of water at 10 days interval treatment was less effective against most of the insects in terms of number of insects and percent reduction of insect pests but it showed better performance than some of the chemical insecticide. It reduced 63.31% aphid, 33.7% whitefly,34.39% stemfly infestation, 14.26% stink bug, 75.30% jassid, 40.38% flea beetle, 44.67% flea beetle infested leaf, 18.38% pod borer infestation at early stage and 45.94% pod borer attack at late pod development stage. It was revealed that Spinosad @0.5 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.) Hepper) belongs to the family Fabaceae, it is rich in protein (Ecocrp 2011, Jansen 2006).It is locally known as '*Mashkalai*' and it is universally grown in both tropical and sub-tropical countries of the world. (Naga *et al*. 2006). Based on archeological evidence blackgram (also known as urd, urad, or mash) mainly found in India domestication may have occurred about 4,500 years ago (Fuller and Harvey 2006). It is extensively cultivated in India, Pakistan, Bangladesh, Myanmar, Thailand, Philippines, China and Indonesia (Poehlman 1991).

Black gram is one of the highly prized pulses crop in Bangladesh. Pulses are considered as "the meat of the poor" because still pulses are the cheapest source of protein and consumed in the form of '*dal*' (whole or split, husked and un-husked) or perched. High values of lysine make blackgram a very good complement to rice in terms of balanced human nutrition. It contains 24% protein, 59% carbohydrates, 10% moisture, 4% mineral and 3% vitamins (Kaul 1982, Khan 1981). Its grains also carried 154 mg calcium, 9.1 mg iron and 38 mg β-carotine per 100 g of split blackgram (Bakr *et al*. 2004). The per capita consumption of pulse in Bangladesh is only 14.3 g day$^{-1}$, which is much lower than WHO advice of 45 g day$^{-}$( HIES 2010, Afzal *et al.* 1999).

The green parts of blackgram can also be used as animal feed and the residues as manure and it is also grown for forage and hay (Gohl 1982). It can be utilize as cover crop and green manure (Jansen 2006).The crop has special importance in intensive cropping system of the country for its short growing duration (Ahmed *et al.* 1978). The crop is potentially useful in improving cropping system as a catch crop due to its rapid growth and development. Blackgram can be used in intercropping systems with legume species such gram, industrial crops cotton (Krishna  2010, Jansefn 2006).

In Bangladesh, blackgram ranks fourth in acreage and production but ranks second in market price. Blackgram is cultivated mainly in the area of 0.188 million hectares contributing 9.5% of total pulse production in Bangladesh (BBS 2005). Although the average yield of blackgram is very low (1.4 to 1.5 t $ha^{-1}$) as compared to other blackgram producing countries (Islam *et al.* 1989).

Black gram can be grown on variety of soils ranging from sandy soils to heavy cotton soil and most ideal soil is a well-drained loam with pH of 6.5 to 7.8. It is sensitive to saline and alkaline soils (Sharma *et al.* 2011). It is a N-fixing legume that improves soil fertility and also improves soil physical properties (Parashar 2006). Its cultivation does not require N fertilization but N fixation is improved by inoculation with local rhizobium strains (Sharma *et al*. 2011). The pulse crops in Rabi and Pre rabi seasons are mostly grown on residual soil moisture condition. In kharif season irrigation is not required, if rainfall is normal and if moisture deficit at pod formation stage irrigation needed to apply. In summer condition 3-4 irrigation required according to crop requirement of blackgram.

The production of blackgram acreage in Bangladesh is gradually decreasing day by day (BBS 2012). Black gram cultivation has been suffering from various problems, such as traditional methods of farming, minimum tillage, no fertilizer, higher insect infestation, no weed management, very early or very late sowing, shortage of key inputs and shortage of irrigation water. A number of insect pest attack blackgram in the field such as stemfly (Prodhan *et al*. 2000, Mia 1998, Rahman 1991), flea beetle, thrips, pod borer (Mia 1998) are the major pests of blackgram in Bangladesh causing serious damage to the crop production 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). Due to *Bemisia tabaci* (Gennadius) and other insect pests in blackgram preventable losses have been reported to range from 17.42 to 71.0% at different locations (Justin *et al*. 2015, Saxena 1983, Chhabra *et al*. 1981).

In our country, for management of insect pests, many options such as chemical, botanical, cultural, mechanical, biological, biorationals, etc are available. But effective control techniques against the blackgram pests are rarely practiced. The blackgram growers use various insecticides to control the insect pests and residues on the sprayed surface of the crops or in the soil have become a matter of concern and environmental pollution (Hussain 1984, Luckman and Metcalf 1978).

Most of the commercially available conventional and synthetic insecticides have broad range toxicity as they target those insect's systems which have physiology exactly like the higher mammals including man. That why they are imposing serious health hazard threats (mutagenic, carcinogenic and teratogenic effects) on human being due to possessing very high mammalian toxicity, long-term residual persistency and high magnification potential. They are also creating many other serious problems like ecological backlashes in pest species, environmental pollution and degradation, threat to biodiversity conservation and loss of beneficial fauna (predators, parasites pollinators etc.). Biorational products/approaches are based on the growth and development as well as communication system of insects which is quite different from higher animals and human being. These products have great potential for replacing the persistent conventional insecticides, confirming effective cost-benefit ratio, tackling ecological backlashes and ensuring food security with safe environment and enhanced exports (Gogi *et al.* 2017).

Under these circumstances it becomes necessary to find out some eco-friendly alternative methods for insect pest management. Biorational pest management under protected cultivation is an important tool for pest suppression in an economically and ecologically sound way (Reddy 2016).

Keeping all these in view, the present study was undertaken to fulfill the following objectives:

1. To observe the incidence of the major insect pests of blackgram.
2. To determine the efficacy of biorational pesticides against insect pest of blackgram.
3. To find out effective insecticides against the major insect of blackgram.

# CHAPTER II

## REVIEW OF LITERATURE

In Bangladesh pulses are the essential legume crops and it is rich in protein (Elias *et al*. 1986). Blackgram is one of the major pulse crops in bangladesh. Blackgram is cultivated in about 161,000 acres of land in Bangladesh and total annual production is about 50,000m tons. The major insect pests effected pulse crops cause substantial losses in yield. In black gram (*Vigna mungo* (L.) Hepper) up to 97 % plants were found to be infested by stem fly ,100% leaves by galerucid beetles(*Madurasia obscurella* Jacoby), and 17% pods by pod borers (BARI 1984).

**Table 1. List of insect pest in blackgram (DAE 2019)**

| Name | Scientific Name | Order | Family |
|---|---|---|---|
| Aphid | *Aphis craccivora* Koch | Hemiptera | Aphididae |
| Whtiefly | *Bemisia tabaci* (Gennadius) | Hemiptera | Aleyrodidae |
| Chinese bruchid | *Callosobruchus chinensis* Linnaeus | Coleoptera | Bruchidae |
| Cowpea weevil/ Cowpea bruchid | *Callosobruchus maculatus* Fabricius | Coleoptera | Bruchidae |
| Hairy caterpillar | *Spilarctia obliqua* (Walker) | Lepidoptrea | Arctiidae |
| Green jassid | *Empoasca kerri* Pruthi | Hemiptera | Jassidae |
| Gram blue butterfly | *Euchrysops cnejus* (Fabricius) | Lepidoptera | Lycaenidae |
| Pod borer | *Helicoverpa armigera (*Hübner) | Lepidoptera | Noctuidae |
| Galeruchid beetle | *Madurasia obscurella* Jacoby | Coleoptera | Chrysomelidae |
| Bean pod borer | *Maruca vitrata* Geyer | Lepidoptera | Crambidae |
| Monolepta beetle | *Monolepta signata* Olivier | Coleoptera | Chrysomelidae |
| Bean stem fly | *Ophiomyia phaseoli* Tryon | Diptera | Agromygidae |
| Crucifer flea beetle | *Phyllotreta cruciferae* (Goeze) | Colepotera | Chrysomelidae |
| Stripped flea beetle | *Phyllotreta striolata* Fabricius | Colepotera | Chrysomelidae |

**2.1 Stem fly**

Stem fly is a serious pest of blackgram at seedling stage (Gupta and Sing 1984). The adults and the larvae cause damage, mainly attack on seedlings in the first 3-4 weeks after emergence. The adults make holes in the young leaves of the plant as they feed and lay eggs. The larvae or maggots attacking the leaves, the tunnel through the leaf stalks and stems moving to the base of the plant to pupate. Decaying of the surrounding pith surface area around the zig-zag tunnels occurs, 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 later die olden plants show weak growth, and the leaves attacked at an earlier stage hang down, and may dry out and fall (Prodhan *et al*. 2000).

Swellings may occur at the junction of stem and root and this causes cracks which may lead to stunting and death. Eggs are white, oval, laid near the leaf stalks of the tender young leaves, mainly in the first ones with a single leaflet, but also in the next two to three leaflets. The eggs hatch, and the maggots grow to about 3 mm. There are three stages over about 10 days, and then the maggots pupate, this occurs at the stem/root junction (or in older plants at the junction of leaf blade and leaf stalk) (Jackson 2015).

## 2.2 Flea Beetle

Adult flea beetles feed externally on plants, eating the surface of the leaves, stems and petals. Under heavy feeding the small round holes caused by an individual flea beetle's feeding may coalesce into larger areas of damage. Some flea beetle larvae (e.g. of *Phyllotreta* sp.) are root feeders.

In adverse weather conditions (rain, for example) some flea beetles seek shelter in the soil. Under favorable conditions, there were two summer generations, adults of the first emerging about-July and those of the second about late August. The adult was the overwintering stage, spring activity occurring during the first extended period of warm weather. Oviposition began shortly after. Eggs, which hatched in about two weeks, were laid in moist soil near the roots of food-plants. The larvae fed on the roots and developed through their three instars in 3-4 weeks. The prepupal and pupal periods lasted 3-6 and 7-9 days, respectively. Development from egg to adult took 6-8 weeks. Plants were most susceptible to injury as seedlings, overwintering adults usually being abundant at that stage of growth; injury to plants sometimes continued throughout the season and could be severe in autumn, when adults were often very abundant (Westdal and Romanaw 1972)

The use of entomopathogenic nematodes (EPNs) within an integrated pest management approach may offer an effective and environmentally safe strategy to suppress outbreaks of this pest. In the present study, the efficacy of *Steinernema carpocapsae* All and *Heterorhabditis indica* LN2 for the control of *P. striolata* in the field was evaluated, as well as the combined application of EPNs and azadirachtin against the pest. Both nematode species were capable of reducing populations of the soil-dwelling stages of *P. striolata*, thus leading to a reduction of the adult populations and the associated shot-hole damage on the leaves (Xun Yan *et al.* 2012). Foliar application of 5% BHC dust effectively controlled *Phyllotreta cruciferae* on mustard [*Brassica juncea*] and C*haetocnema basalis* on wheat. 3-5% DDT dust gave effective control of *Luperodes* sp. on sunn hemp (Batra 1969).

**2.3 Aphid**

Aphid is a small, soft-bodied (meaning that the exocuticle part of the exoskeleton is greatly reduced. Large numbers of aphids cause stunting of the plants. Beans suffer damage to flowers and pods which may not develop properly. The plants are stunted by the removal of sap, the stems are distorted, harmful viruses are transmitted, and aphid residues may contaminate the crop (Godfrey and Trumble 2009).

Aphids need to suck large volumes of sap. The excess sugary fluid, honeydew, is secreted by the aphids. It adheres to plants, where it promotes growth of sooty molds. These are unsightly, reduce the surface area of the plant available for photosynthesis and may reduce the value of the crop various chemical treatments are available to kill the aphids and organic growers can use a solution of soft soap (Godfrey and Trumble 2009). In most cases, a combination of these biological control agents work in concert to reduce aphid numbers (Summer *et al*. 1997).

## 2.4 White fly

The Aleyrodidae are a family in the suborder Sternorrhyncha and several species of whitefly may cause some crop losses simply by sucking sap when they are very numerous, the major harm they do is indirect. Firstly, like many other sap-sucking. Next, they inject saliva that may harm the plant more than either the mechanical damage of feeding or the growth of the fungi.

Whiteflies attacking by tapping into the phloem of plants, initiate toxic saliva and decreasing the plants overall turgor pressure. The adult is a mainly small 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 randomly on the under surface of the young leaves (Hirano *et al*. 1993). Vegetative plant may even be killed in case of severe whitefly infestation (Srivastava and Singh 1976). The affected plant parts become yellowish, the leaves become wrinkle, curl underside and eventually they fallen off. This happens mainly due to viral infection whereas whitefly acts as a mechanical vector of many diseases. The infested plants became enfeeble 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).

### 2.5 Pod Borer

Tropical and sub-tropical countries pod borer is one of the most serious preharvest pest of blackgram (Mia 1988, Sehgal and Ujagir 1988). It is the major pest of blackgram. The larvae feed on the flower buds and mainly bore into the pod to eat the developing seeds. Pod borer moths are active at night but shelter within the plant canopy during the day. The flowers and pods are bound together by frass-covered web produced by the larva. It is a polyphagous pest, infesting gram, lablab, safflower, chillies, groundnut, tobacco, cotton etc.

### 2.6 Life cycle

Crops may be infested from early budding development stage. The eggs are laid on or in the flowers buds. Young larvae eat inside flowers for 5-7 days before moving to the pods when middle-sized. Suitable entry points are where flowers and pods are touching. After completing their development (10-15 days from egg hatch), larvae exit pods and pupate in the soil. Larvae can reach 18 mm in length. Seeds within damaged pods are fully or partially eaten out by pod borer larvae. Entry holes also let in water, which stains the remaining non-eaten seeds.

### 2.7 Biology

#### 2.7.1 Egg

Spherical, yellowish eggs are laid singly on caring parts and buds of plants. The egg period lasts for 2-5 days. The freshly laid eggs are yellowish 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. It is longer in cold weather and shorter in hot weather conditions (Singh and Singh 1975).

### 2.7.2 Larva

Early stage brown and later turn greenish with darker broken lines along the side of the body. Full body covered with radiating hairs. The larval period duration for 18-25 days. The full grown caterpillar pupates in the soil. The newly hatched larva of pod borer is translucent and it is yellowish white color with faint yellowish orange longitudinal lines. The head of the pod borer is reddish brown. Thoracic, anal shields and legs were brown but the setae dark brown in color and body covered with short hairs. (Singh and Singh 1975). Pod borers are generally six larval instars (Bhatt and Patel 2001). But during the cold season of low temperature, when larval development is generally prolonged.

### 2.7. 3 Pupae

Pupation takes place inside the soil in an earthen cell. The pod borer pupa undergoes a facultative diapauses and 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 recorded from 14 to 20 days in Gujarat, India (Bhatt and Patel 2001).

### 2.7.4 Adult

Moth is stout, medium sized with brownish/greyish forewings with a dark cross band near outer margin and dark spots near costal margins, with a wing expanse of 3.7cm.

Adult female pod borer is a stout-bodied moth, 18 to 19 mm long. Tuft sof thairs are located 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).

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

Biology of pod borer *Maruca testulalis*, the results revealed that eggs were laid on the under surface of leaves, terminal shoots and flower buds. The freshly laid eggs were milky white in colour and oval in outline, dorsoventraly flattened and glued to the surface. The incubation period varied from 2.54±0.04 days. The first, second, third, fourth and fifth instar larval duration were 1.28±0.07, 1.35±0.10, 1.50±0.05, 2.08±0.16 and 3.50±0.25 days, respectively. Pre-pupal and pupal period were 2.10±0.50 and 8.00±0.85 days, respectively. Total developmental period *M. testulalis* occupied 22.36±1.45 days. Pre-mating period of *M. testulalis* was 3.22±0.84 days. Pre-oviposition and oviposition periods were 1.34±0.36 and 4.60±3.45 days, respectively. Fecundity was 126.8±103.2 eggs per female whereas viability of eggs was 95.45±2.54% (Naveen *et al.* 2009).

**2.8 Effect of chemical and botanical on insect pest management of blackgram**

Tahir and Shaheen (2019) revealed that investigation was to evaluate the effectiveness of locally isolated nematodes in controlling *H. armigera* in the field. *O. nadarajni* (3x103IJs) along with the glycerin, robin blue, sugar solution & sodium bicarbonate found much more effective than the *O. nadarajni* at 2x103IJs & *O. nadarajni* at 1x103IJs but all the formulations were effective and help in increased yield and decreased pod damage. *O. nadarajni* proved effective against *H. armigera*. So it can be used in future to regulate the effect of the insect pests on the crop.

Nikul *et al.* (2018) conducted the experiment Nine treatments of different botanicals and absolute control were evaluated in a field experiment against lepidopteran insect pest infesting black gram under Randomized Block design in the year Kharif 2016 at B. A. College of Agriculture, Anand Agricultural University, Anand. Among the different botanicals, Azadirachtin 0.15 EC 0.0006 percent, Neem Seed Kernel Extract (NSKE) 5 percent, neem oil 0.3 percent and neem leaf extract (NLE) 10 percent were found highly effective in managing Spilosoma obliqua Walker and Maruca testulalis (Geyer) in black gram. A treatment of Azadirachtin 0.15 EC 0.0006 percent, NSKE 5 percent neem oil 0.3 percent and neem leaf extract 10 percent registered the higher grain yield of black gram.

Jat and Rana (2018) investigation on, “management of major insect pest of blackgram under organic farming” was carried out at the Instructional Farm, Rajasthan College of Agriculture, Udaipur during monsoon (July, 2013) and (July, 2014) seasons with the objectives to study the qualitative and quantitative abundance of major insect pests of blackgram and their associated natural enemies. The aphid pest recorded on blackgram was *Aphis craccivora* (Koch). Among the aphidophagous predatory guild, the major insect groups included, coccinellids, *Coccinella septempunctata*(L); *Cheilomenes sexmaculata* (Fab.) and syrphid flies, *Ischiodon* sp. were recorded feeding aphids on blackgram; the carabid, *Chlaenius aspericollis* (Bates); spiders; reduviid predatory bugs and wasps were also collected from the crop area. The seasonal mean population of aphids was higher during 1st week of September ($36^{th}$SMW) during 2013 and 2ndweek of September ($37^{th}$SMW) during 2014 with mean population of 42.33 and 37.33 aphids/5 plants in the respective years. The mean dens-ity and relative density values were the maximum (8.0 & 78.27 %) for coccinellids during 2013, followed by that for syrphid fly (2.78 & 21.73 %) and relatively more as compared to 2014.

Gowshhami (2016) conducted the 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) @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 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.

Ahirwar *et al.* (2016) reported that The population of jassids, thrips and whitefly increased in the fourth week of April when prevailing temperature ranged between

19.8–41.9°C and relative humidity 43 to 93%. Imidacloprid greatly minimized the population of jassid (1.11in 2010 & 1.08 in 2011/plant) followed by thiomethaxam (1.12 in 2010 & 1.00 in 2011/plant). In case of thrips, thiomethaxam found more effective (1.54 in 2010) and (0.85 in 2011/plant) in managing the pest in comparison to other used insecticides whereas chloropyriphos (2.69) and dimethoate (2.71) had least effect. Acitamiprid (1.19 in 2010 and 1.70 in 2011/plant) noted more effective against the white fly population than thiomethaxam (0.97) and imidacloprid (1.10). Significantly more yield was recorded in the imidacloprid 1633 kg/ha (2010) 1667 kg/ha (2011) than chloropyriphos and acephate. There was only 722 kg/ha yield in 2010 and 813 kg/ha in 2011 in control treatment.

Justin *et al*. (2015) conducted that 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 25WG @0.4g/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.

Yadav *et al.* (2015) reported that indoxacarb 14.5% SC and abamectin 1.9% EC were found to be most effective in reducing larval population of *Spodoptera litura* and *Spilosoma obliqua* whereas, indoxacarb 14.5% SC and emamectin benzoate 5% WG were found significantly better to reduce larval population of *Trichoplusia ni*. The treatments of emamectin benzoate 5% WG and indoxacarb 14.5% SC were found the most effective in reducing the pod borer damage with high grain yield of black gram. Yadav Sunil *et al.* (2015) Suggested that thiamethoxam 25% WG, acetamiprid 20% SP and triazophos 20% EC were found to be the most effective in reducing the population of whitefly and leafhopper. The treatments of azadirachtin 0.03% EC, jatropha oil and *Beauveria bassiana* 5% WP were found relatively less harmful whereas, indoxacarb 14.5% SC was observed relatively toxic to the coccinellid beetles.

Parmar (2015) suggested that Among the tested eleven insecticides, the higher effectiveness was observed with the application of clothianidin 50 per cent WDG (0.003%) against whitefly, jassid and aphid. While, spinosad 2.5 SC (0.002%) was the most effective against gram pod borer and spotted pod borer.

Sharma and Singh (2015) reported that during the Kharif season of 2012 and 2013 for knowing the competitive study of insecticides as foliar application for the control of sucking pests such as jassid, thrips and whitefly in urdbean in relation to yield gap. maximum yield in 2012 was found in imidacloprid treated plot (11.33q/ha) followed by thiamethaxam (10.88q/ha) and acetamiprid (10.77q/ha) in comparison to trizophos (9.55q/ha) and monocrotophos (8.55q/ha). However, malathian and chloropyriphos had least effect on increase the yield. Only 5.22q/ha yield was found in control plot. In the year 2013, thiamehaxam gave better results in increasing the yield (11.93q/ha) than other tested insecticides.

Justin *et al.* (2015) conducted that 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. evident that  the seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4g/ l was found to be effective against black gram aphid and leafhopper and indoxacarb 14.5 SC @ 1 ml/ l was the efficacious insecticide against *S. litura* and *H. armigera*.

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 @ 250g a.i $ha^{-1}$.

Shivaraju *et al.* (2011) conducted the experiment Effect of indigenous materials and new insecticide molecules against *Maruca testulalis* on blackgram revealed that among indigenous materials NSKE recorded comparatively high larval reduction (36.26%) followed by GCK (21.43%) and Panchagavya (18.35%) whereas GE (11.50%) was recorded lowest larval reduction in first spray. Similarly, NSKE (55.34%) and Panchagavya (55.34%) recorded comparatively high larval reduction followed by GCK (54.08%), whereas GE (49.13%) was recorded lowest larval reduction in second spray. Among new insecticide molecules flubendiamide 24%+thiacloprid 24-48%SC recorded comparatively high larval reduction (76.56 and 84.45%) followed by emamectin benzoate (66.50 and 80.88%) and indoxacarb (61.55 and 77.94%) lowest larval reduction in I and II spray, respectively.

Sonun *et al.* (2010) revealed that spinosad 0.009%, indoxacarb 0.008%, profenophos 0.05% and lambda cyhalothrin 0.005% were found the most effective in reducing the larval population of *M. vitrata* and also to reduce the pod damage of blackgram. The maximum per cent increase in seed yield (79.37%) of blackgram over control was recorded in the treatment of spinosad 0.009%. profenophos 0.05% or lambda cyhalothrin 0.05% or endosulfan 0.07% or profenophos 40 EC + cypermethrin 4 EC (0.044%) or indoxacarb 0.008% or spinosad 0.009%, first at the time of 50% flowering and second at 15 days after first spray can be suggested to the farmers for controlling this pest on blackgram and to get more benefit during the *kharif* season.

Gupta and Pathak (2009) reported that. Efficacy of some indigenous neem products, insecticides and their admixtures were tested at Research Farm of College of Agriculture, Tikamgarh during kharif 2003-2005. The admixture treatments, neem seed kernel extract (NSKE) (in cow urine), 3% + dimethoate, 0.03% and neem oil, 0.5% + dimethoate, 0.03% not only reduced the incidence of whitefly and yellow mosaic but also of pod borer. These treatments gave maximum grain yield of 935 and 902 kg/ha, net profit of Rs 3934 and Rs 3320/ha with incremental cost benefit ratio of 11.2 and 10.9, respectively.

Kumar and Shivaraju (2009) reported that the newer insecticide molecules evaluated against pod borers of black gram (*Helicoverpa armigera* (Hubner) and *Etiella zinckenella* Treit), larvin 75 WP @ 468.75 g a.i./ha, larvin 75 WP @ 562.5 g a.i/ha, flubendiamide 480 SC @ 36 g a.i./ha and flubendiamide 480 SC @ 48 g a.i./ha were superior in recording less larval populations of both the pod borers.

Patil and Jamadagni (2008) revealed that testing of thiodicarb 75 WP @ 375.00, 468.75 and 562.50 g.a.i./ha, endosulfan 35 EC @ 750 g.a.i./ha, chlorpyriphos 20 EC @ 400 g.a.i./ha and quinalphos 25 EC @ 500 g.a.i./ha, was done for their efficacy against pod borers in black gram. The lowest pod damage of 5.0% was recorded in thiodicarb 75 WP @ 562.50 g.a.i./ha followed by chlorpyriphos (5.3%) and endosulfan (5.6%). The maximum grain yield of 1114 kg/ha was noticed with the treatment of chlorpyriphos 20 EC @ 400 g.a.i./ha followed by endosulfan 35 EC @ 750 g.a.i./ha (985 kg/ha) and thiodicarb 75 WP @ 562.50 g.a.i./ha (966 kg/ha). However, the highest per Rs. return gained with chlorpyriphos (7.86) followed by endosulfan (4.19) and quinalphos (2.72). Alice *et al.* (2007) experiment was conducted to assess locally-available botanicals and oils for their ability to protect black gram seeds from infestation by the pulse beetle *Callosobruchus maculatus*. The treatments comprised: castor oil, gingelly oil and neem oil at 1%; neem seed kernel extract powder, neem leaf powder, pungam leaf powder, ash at 3%; malathion 50 EC at 0.05%; and the control. There were significant differences among the treatments at 45, 90, 120 and 150 days. The overall mean showed the lowest *C. maculatus* infestation when black gram was treated with 1% neem oil.

### 2.9 Biorational management of insect pest of blackgrams and others similar pulse crops

Khajuria *et al*. (2015) suggested that IPM Module-I: i.e., spray of neem oil 0.03% after days 30and 45 of sowing, followed by dimethoate @ 0.03% as the last spray can manage the sucking pests and YMV disease of black gram effectively in semi-arid region of central Gujarat.

Khade *et al.* (2014) observed that "Biorational management of sucking pests of cowpea *Vigna sinensis* L." Among the chemical insecticides highest yield over control was observed in Imidacloprid i.e. 45.27 q/ha, and the lowest were observed in Difenthiuron i.e. 41.95 q/ha, among the bio pesticides highest yield over control was observed in Neem oil 38.59 q/ha and lowest increase over the control observed in Verticillium lecanii i.e. 30.03q/ha.

Hari *et al.* (2014) reported that the bioefficacy of indigenous oils *i.e*. groundnut, mustard, sunflower, mahua, linseed, neem, sesame, taramira, coconut and soybean against the pulse beetle, *Callosobruchus chinensis* on *Vigna mungo.*

The neem oil was noticed as effective grain protectant had maximum reduction in fecundity (89.1%), emergence of $F_1$ adult (97.9%) and increase developmental period (14.4) at 3 ml/kg seed dose.

Ram and Paras (2011) reported that The intercropping had significant difference in reduction of pod damage, grain damage (in number & by weight basis) as compare to pigeon pea monocrop. The two sprays of biopesticides were found most effective in reducing crop losses incurred by pod bug. The intercrops pigeon pea + rice, pigeonpea + sorghum and two sprays of NSKE 5% were found most effective combination for the management of pod, grain and grain weight loss by *Clavigralla. gibbosa.* The plots devoid of biopesticidal treatment had 15.8 to 16.8%, 6.3 to 7.3% and 3.4 to 4.8% pod damage, grain damage and grain weight loss.

Gopala *et al*. (2010) evaluate the efficacy of certain biorational approaches against the pulse beetle (*Callosobruchus chinensis*) in stored blackgram. In blackgram treated with pepper powder @ 1.0 per cent and Ac 10D @ 2.0 per cent, there was significantly less weight loss (1.70%) and grain damage (0.67%) at 150 days after release with minimum progeny development (18.0 and 20.7 adults, respectively) as compared to untreated control (15.31% weight loss and 44.0% grain damage.

## 2.10 Effect of chemical and botanical pest management on others similar pulse crops

Singh *et al*. (2018) present investigation revealed that three species of insect-pests viz. white fly (*Bemisia tabaci*), jassid (*Empoasca kerri*) and thrips (*Caliothrips indicus*) were found as major insect-pests of mungbean on the basis of their population build up and severity of infestation. White fly, jassid and thrips attacked the mungbean from seedling to maturity stage. Among the microbial and chemical insecticides combination of seed treatment with *Pseudomonas florescens* + *Beauveria bassiana*(spraying) gave better response and was found most effective against white fly followed by seed treatment with *Pseudomonas florescens.* Similarly, in case of jassid, the seed treatment with imidacloprid gave better result followed by combination of seed treatment with *Beauveria bassiana*+ *Pseudomonas florescens.* In case of thrips, combination of seed treatment with *Beauveria bassiana* gave best performance with lowest thrips infestation and highest reduction over control, followed by the seed treatment with imidacloprid. All the insecticides found to be effective in increasing the yield over control. The highest yield (6.98) q $ha^{-1}$was recorded in combination of seed treatment with *Beauveria bassiana* and spray with profenophos followed by combination of seed treatment with *Pseudomonas florescens*+ spray with *B. bassiana* (6.42 q $ha^{-1}$).

Iqbal *et al.* (2015) study was conducted to evaluate one combination of seed treatment with imidacloprid (Confidor 70 WS) and spray with detergent and for insecticide sprays: imidacloprid (Confidor 20% SL), acetamiprid (Acelan 20% SL), thiomethoxam (Actara 25 WG) and acephate (Commando 75 SP), against sucking insect pests on mungbean, *Vigna radiata* (L.) at Arid Zone Research Institute (AZRI), Bhakkar(2012) revealed that all the treatments showed a significant difference with one another, regarding their effectiveness. The application of insecticide sprays immediately enhanced the mortality of the pests, whereas, the effect of seed-treatment and detergent did not show distinctive effect on the pests' population. Imidacloprid and thiomethoxam resulted in a maximum mortality of the jassid, followed by acetamiprid. While in case of whitefly, imidacloprid was the most effective and resulted in a minimum population followed by acetamiprid. Acephate resulted in the maximum control of thrips and was found the most effective insecticide, followed by acetamiprid. A field experiment conducted Hossain (2015) efficacy and profitability of insecticidal management practices using different insecticides were tested against insect pests of mungbean at Pulses Research Center, Ishurdi, Pabna, Bangladesh during two consecutive seasons of kharif-1 2013 and 2014. Insect infestations were reduced significantly by the application of synthetic insecticides. Spraying of Imidachloprid (Imitaf 20 SL) @ 0.5 ml/l of water showed the best efficacy in reducing flower infestation and thrips population followed by Fipronil (Regent 50 SC). Spraying of Thiamethoxam + Chlorantraneliprol (Voliam flexi 300 SC) @ 0.5 ml/l of water showed the best efficacy in reducing pod borer and flea beetle infestations. Spraying of Fipronil (Regent 50 SC) performed highest efficacy against stemfly infestation. The yield and the highest net return were obtained from Voliam flexi 300 SC, the highest benefit was obtained from Regent 50 SC treated plots. This might be due to the higher cost of Voliam flexi that reduced the profit margin and showed the lower marginal benefit cost ratio (MBCR) compared to Regent. Therefore, considering the efficacy and benefit, spraying of Fipronil (Regent 50 SC) @ 0.5 ml/l is the most profitable insecticidal management approach against insect pests of mungbean followed by Imidachloprid (Imitaf 20 SL) at the same dose.

Panduranga *et al.* (2012) results revealed that foliar spray of thiomethoxam 25 WS @ 0.005% followed by spirotetramat 150 OD @ 90 g a.i./ha and acetamprid 20% SP @ 0.002% were found to be the most effective treatments and recorded low population of whiteflies (2.66, 3.44 & 4.88/5 plants, respectively) and low mungbean yellow mosaic virus (MYMV) incidence ranging from 10.7% to 14.2%. Seed treatment with thiomethoxam 25 WG @ 0.0035% and imidacloprid 70 WS @ 0.0035% though protected the crop from whiteflies up to 25 days after sowing but later resulted in more vector population (6.00 & 7.33/5 plants) and high MYMV incidence (19.8% & 24.3%) than the other treatments.

Nitharwal (2009) conducted the study three insect pest species, viz., jassid, *Empoasca motti* Pruthi, whitefly, *Bemisia tabaci* (Genn.) and thrips, *Caliothrips indicus* appeared as major pests which commenced from first week of August and remained throughout the crop season. Mainly, *Chrysoperla carnea*(Steph.) and *Coccinella septempunctata* L. were found predating the insect pests of green gram. The dimethoate 0.03% and imidacloprid 0.005% followed by thiamethoxam 0.025% proved most effective for the control of jassid, whitefly and thrips. Maximum seed yield and benefit cost ratio was recorded from the plots treated with dimethoate 0.03% followed by imidacloprid 0.005% and thiamethoxam 0.025%. The treatment of karanj extract 5 ml $l^{-1}$, azadirachtin 5 ml $l^{-1}$, *M. anisopliae*1x108spores $l^{-1}$and *B. bassiana*1x108spores $l^{-1}$were observed least toxic to *C. carnea*.

## CHAPTER III

## MATERIALS AND METHOD

The materials and methods of this research work are described in this chapter as well as on experimental materials, site, climate and weather, land preparation, experimental design, lay out, data collection on major insect pests and their incidence, grain yield etc. The details description of the materials and methods for this experiment have been given below under the following headings-

### 3.1 Description of the experimental site

#### 3.1.1`Experimental period

The experiment was conducted from 29 August to 15 November, 2019.

#### 3.1.2 Experimental location

The present experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka and it is located in $23.74^0$N latitude and $90.35^0$E longitude with an altitude of the location was 8.2 m from the sea level (Khan 1997).

#### 3.1.3 Characteristics of soil

The 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). Soils were clay loam in texture on Upper level, olive-gray through common fine to medium distinct dark yellowish brown mottles under the Agro- ecological Zone (AEZ- 28) and belonged to the Madhupur Tract (FAO 1988, UNDP 1988). The experiment field was above flood level and sufficient sunshine was available and irrigation, drainage system during the experimental period. A composite soil samples from 0-15 cm depths were collected from experimental field. The analyses were done from Soil Resources Development Institute (SRDI), Dhaka. The experimental field was fertile, high land, well drained. The soil was having a texture of silty clay loam with pH and organic matter 5.8 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 Climate and weather

The experimental site is situated in the sub-tropical climatic zone 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. Heavy rainfall during the months of May to October (Kharif ll Season). 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 %).

### 3.2 Crop Cultivation

#### 3.2.1 Variety

Blackgram variety BARI mash-3 (*Hemonto*) was used as experimental materials for the study and the seed of the variety of this experiment collected the Pulse Seed Division of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. It was developed through hybridization between line BMA-2140 and BMA-2038 and this variety is resistant to yellow mosaic virus.

#### 3.2.2 Treatments of the experiment

The experiment comprised of seven treatments including an untreated control. The details of the treatments are given below:

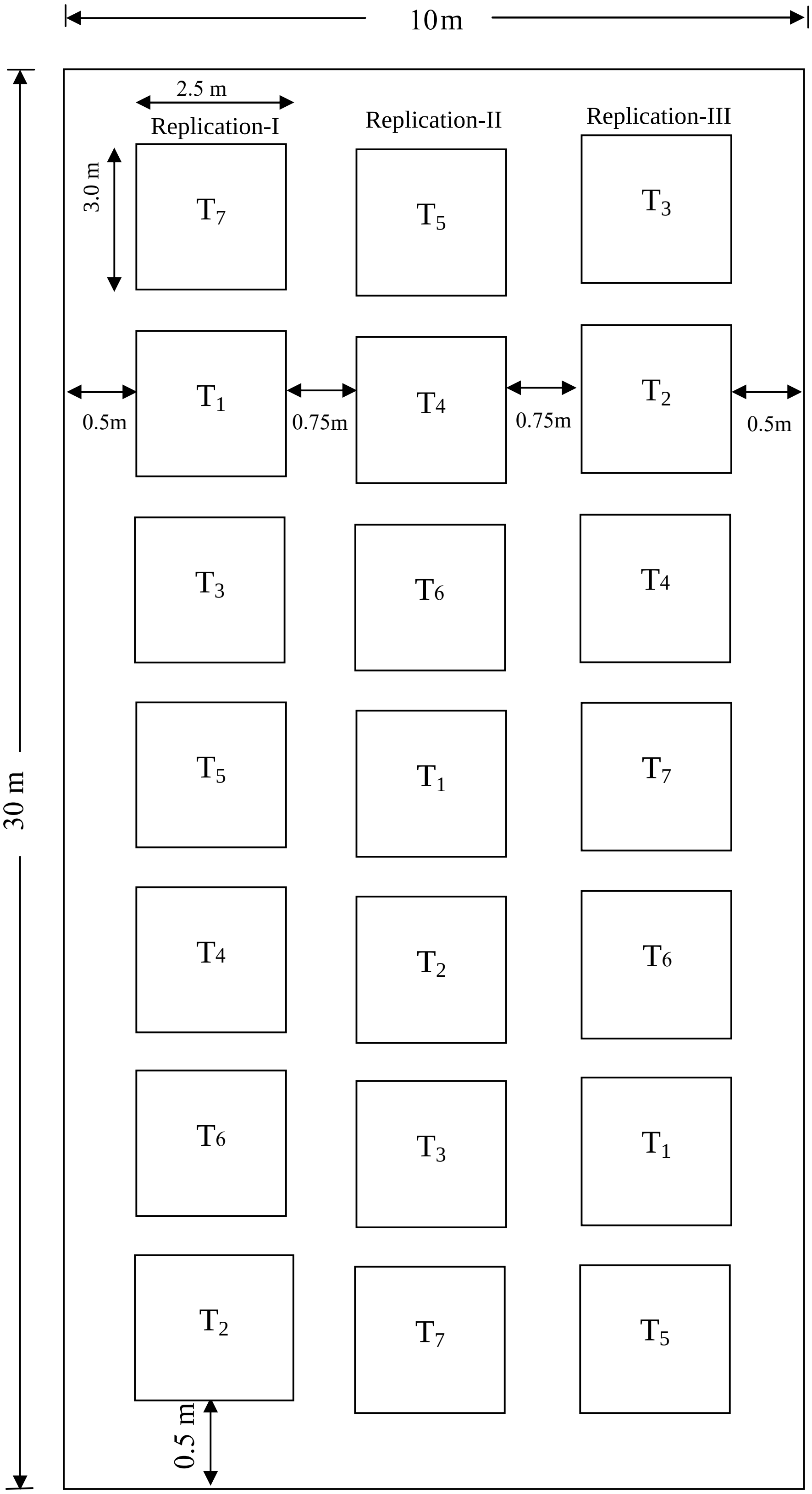
**Table 2.** Different treatments name, their dose and application interval

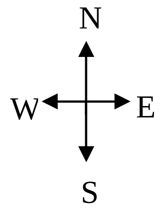
| Treatments | Dose | Application Interval |
|---|---|---|
| $T_1$= Spinosad | 0.5 ml $l^{-1}$ of water | 10days |
| $T_2$= Emamectin Benzoate | 1.0 ml $l^{-1}$ of water | 10 days |
| $T_3$= Lufeneuron | 0.2g $l^{-1}$ of water | 10days |
| $T_4$= Matrine | 1 ml $l^{-1}$ of water | 10days |
| $T_5$ = Thiamethoxam | 0.5 g $l^{-1}$ of water | 10days |
| $T_6$=Neem seed kernel | 5g $l^{-1}$of water | 10 days |
| $T_7$= Untreated Control | Water | 10 days |

#### 3.2.3 Land preparation

Preparation of the experimental field was done by power tiller drawn disc plough. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed, cross-ploughed and harrowing to obtain the desirable tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of this crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The first ploughing and the final land preparation were done on the 21 and 29 August, 2019, respectively.

**Experimental design and layout**




Plot size: 3.0 m × 2.5 m

Plot spacing: 0.50 m

Between replication: 0.75 m

**Treatments**

$T_1$: Spinosad @0.5 ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2 g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water at 10 days interval

$T_5$: Thiamethoxam @0.5g /l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/l of water at 10 days interval

$T_7$: Untreated control

Figure 1. Layout of the experimental plot

### 3.2.4 Fertilizers

The fertilizers were applied as per fertilizers recommendation guide Bangladesh Agricultural Research Institute (BARI). Applied manures were mixed properly with the soil in the plot using a spade. The dose and method of application of fertilizers are shown below:

**Table 3.** Name of fertilizers and their recommended dose

| **Fertilizers** | **Dose (kgha$^{-1}$)** |
|---|---|
| Urea | 50 |
| TSP | 85 |
| MoP | 35 |
| Gypsum | 5 |

### 3.3 Growing of crops

### 3.3.1 Sowing of seeds

Blackgram seeds were sown on the 29 August 2019. The seeds were sown in furrows having a depth of 2-3 cm and the furrows were covered with soils soon after seeding. Row to row distance was 30 cm.

### 3.3.2 Germination of seeds

Seed germination occurred from 3$^{rd}$ day of sowing. On the 4$^{th}$day the percentage of germination was more than 80% and on the 5$^{th}$day nearly all the seedlings came out from the soil.

### 3.3.3 Intercultural operations

#### 3.3.3.1 Thinning out

Thinning needed when seeds were sown continuously into the line, as there were so many seedlings. Emergence of seedling was completed within 15 days after sowing. Densely seedlings were thinned out twice. First thinning was done after 15 days of sowing which was done to remove unhealthy and out of line seedlings. The second thinning was done 10 days after first thinning.

#### 3.3.3.2 Gap filling

Seedlings were transferred to fill in the gaps where seeds failed to germinate. The gaps were filled in within two weeks after germination of seeds.

#### 3.3.3.3 Weeding

So many weeds were found in the blackgram field. First weeding was done at 20 DAS and then once a week to keep the plots free from weeds and to keep the soil loose and aerated.

#### 3.3.3.4 Irrigation and drainage

Crops were grown under rainfed condition and no need to irrigation. The experimental field had proper drainage system to remove out excess water from the experimental plot.

#### 3.3.3.5 Procedure of spray application

The desire amount of each chemical insecticide was taken in knapsack sprayer having pressure of 4-5 kg $cm^{-2}$ and thoroughly mixed with water and sprayed in the respective plot. The required amount of liquid insecticides was taken by measuring cylinder in the sprayer. Each treatment was repeated at 10 days interval applied in the field. Precaution 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 newly prepared.

### 3.4 Crop sampling and data collection

Each treatment was randomly marked five plants from 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

Plate 3: Aphid infested blackgram leaves

Plate 4: Whitefly infested blackgram leaves

Plate 5: Pod borer infestation on blackgram pod at early stage

Plate 6: Pod borer infestation on blackgram pod at late stage

Plate 7: Stink bug infested blackgram leaves

Plate 8: Flea beetle infested blackgram leaves

### 3.4.1 Monitoring and data collection

The blackgram plants of biorational management 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
- Aphid infested plant
- Number of flea beetle per plant
- Flea beetle infested leaf
- Number of jassid per 10 leaves
- Number of whitefly per 10 leaves
- Number of stinkbug per plant
- Number of healthy pods at early and late stage
- Number of infested pods at early and late stage by pod borer.
- Pod infestation (%) in number at early and late stage
- Plant height (cm) at harvest
- Number of pods per plant
- Pod yield per hectare(ton)

### 3.4.2 Determination of stemfly infestation by number and infestation reduction over control

All the stemfly were counted from 5 randomly selected plants from middle rows of each plot and monitored. The number of stemfly were counted very early in the morning and the percent reduction over control was calculated using the following formula:

Infestation in control- Infestation in the concerned treatment

$$\text{Infestation reduction (\%)} = \frac{\quad}{\text{Infestation in control}} \times 100$$

### 3.4.3 Determination of white fly infestation by number and infestation reduction over control

All the whiteflies were counted from 5 randomly selected plants and then 10 leaves form each was used in monitoring insect. The number of whitefly were counted very early in the morning and the percent reduction over control was calculated using the following formula:

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

### 3.4.4 Determination of jassid infestation by number and infestation reduction over control

All the jassid were counted from 5 randomly selected plants and then 10 leaves form each was used in monitoring insect. The number of jassid were counted very early in the morning and the percent reduction over control was calculated using the following formula:

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

### 3.4.5 Determination of aphid infestation by number and infestation reduction over control

All the aphid was counted from 5 randomly selected plants and monitored insect. The number of aphid were counted very early in the morning and the percent reduction over control was calculated using the following formula:

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

### 3.4.6 Determination of flea beetle infestation by number and infestation reduction over control

All the flea beetle was counted from 5 randomly selected plants and monitored insect. The number of flea beetle were counted very early in the morning and the percent reduction over control was calculated using the following formula:

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

### 3.4.7 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 recorded. The collected data were divided into early and late pod development stage. The healthy and infested pods were counted at early and late stage and the percent pod damage was calculated using the following formula:

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

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

## 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.

#### 3.6.4 Economic analysis

Economic analysis was done in order to compare the profitability of the treatment combination. Only the cost of insecticide was considered for computing the cost of production. The price of 1 kg blackgram after harvest was considered to be Tk. 130.

Gross return = Marketable yield x Tk/ton

Net Return = Gross return - Total cost of production

Adjusted Net Return = Net returns – Net return of untreated control ($T_7$)

The benefit cost ratio (BCR) was calculated as follows:

$$BCR = \frac{\text{Net Return (Tk/ha)}}{\text{Total cost of production}}$$

### 3.6.5 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-XVIII. 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 insects on blackgram

The comparative population dynamics of insects from untreated control plot in relation to plant age is shown in figure 2. The graph expresses that the population of all insects was increased with plant age and aphid, whitefly and stemfly was reached maximum at 7th week, but in flea beetle it was at 5$^{th}$ week and in pod borer it was at 9$^{th}$ week after germination and then declined with plant age. The aphid (*Aphis craccivora*) was the most abundant insect and whitefly (B*emisia tabaci*) was the second highest insect attacking blackgram. Flea beetle(*Phyllotreta vittula*)population occupied the 3rd position, pod borer (*Maruca vitrata*)population occupied the 4$^{th}$ position, stemfly (*Ophiomyia phaseoli*) population occupied the 5$^{th}$ position and jassid (*Amrasca biguttula*) was found lowest on blackgram during the cropping season.

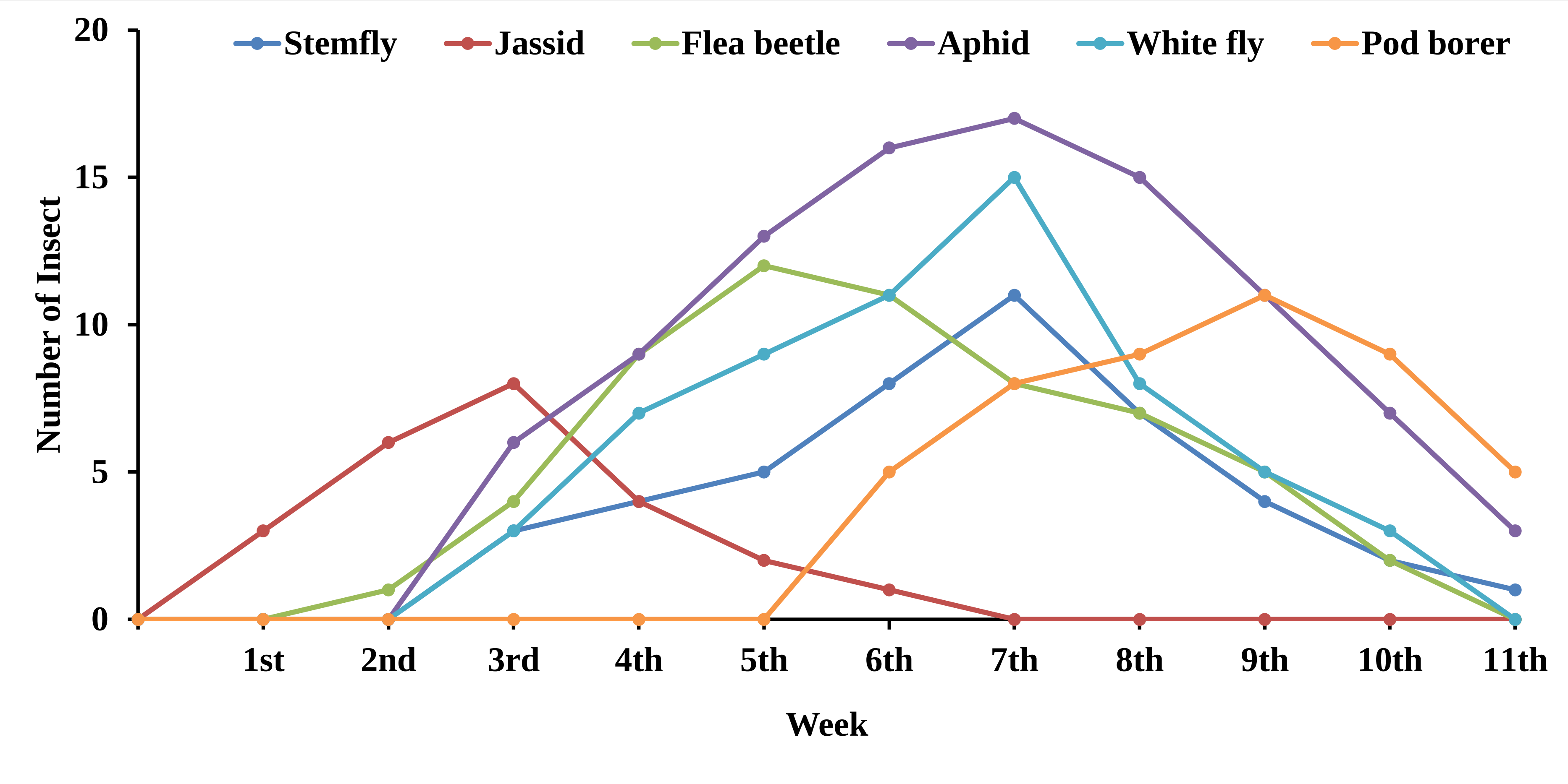



Figure 2. Population dynamics of insects on blackgram throughout the cropping season

## 4.2 Incidence of aphid on blackgram under different treatments

The average population of aphid in blackgram under different treatments has been shown in Table 4. The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. The data (Table 4) express that the lowest number of aphid (3.30/plant) was observed in $T_1$ (Spinosad) treated plot followed by $T_5$ (Thiamethoxam) treated plot (4.03/plant) having significant difference between them. Other insecticides have intermediate number of aphid. Matrine showed poor results (9.13/plant) in reducing aphid population. However, the highest number of aphid (16.53/plant) was found in control plot which was significantly higher than all other treated plots.

Similarly, $T_1$ (Spinosad)showed the best performance (80.05%) in reduction of aphid population over control followed by $T_5$ (Thiamethoxam) treated plot (75.60%)having significant difference between them. Matrine showed poor results (44.75%) in reducing aphid population over control. Neem seed kernel showed 63.31% reduction over control. However, only Spinosad insecticides gave standard level of reduction (80%) of aphid population. The results of the study revealed that all the insecticides significantly reduced aphid population infesting blackgram.

However, Spinosad was the most effective insecticide against aphid and Thiamethoxam was second effective insecticides but Emamectin Benzoate, Matrineand Lufeneuronwere less effective insecticides. Neem seed kernel was also less effective against aphid infesting blackgram in field condition. The order of effectiveness is Spinosad>Thiamethoxam> Emamectin Benzoate >Neem Seed Kernel >Lufeneuron> Marine.

**Table 4: Effect of biorational insecticides on the incidence of aphid on blackgram**

| Treatment | Number of Aphid $Plant^{-1}$ | % Reduction over control |
|---|---|---|
| $T_1$ | 3.30 g | 80.05 a |
| $T_2$ | 5.17 e | 68.73 c |
| $T_3$ | 7.07 c | 57.26 e |
| $T_4$ | 9.13 b | 44.75 f |
| $T_5$ | 4.03 f | 75.60 b |
| $T_6$ | 5.73 d | 63.31 d |
| $T_7$ | 16.53 a | -------- |
| SE | 0.169 | 1.0634 |
| CV (%) | 3.98 | 2.84 |
| $LSD_{(0.05)}$ | 0.2384 | 3.3507 |

$T_1$: Spinosad @0.5 ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water

$T_5$: Thiamethoxam @0.5g /l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/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.

### 4.3 Incidence of whitefly on blackgram plant

The average population of whitefly in blackgram plant under different treatments has been shown in Table 5. The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. The data (Table 5) express that the lowest number of whitefly (4.03/plant) was observed in $T_5$ (Thiamethoxam) treated plot followed by $T_1$ (Spinosad) treated plot (5.00/plant) having significant difference between them. Other insecticides have intermediate number of whitefly. Neem seed kernel extract showed poor results (8.97/plant) in reducing whitefly population. However, the highest number of whitefly (13.60/plant) was found in control plot which was significantly higher than all other treated plots.

Similarly, $T_5$ (Thiamethoxam) showed the best performance (70.16%) in reduction of whitefly population over control followed by $T_1$ (Spinosad) treated plot (63.17%)having significant difference between them. Neem seed kernel extract showed poor results (33.77%) in reducing whitefly population over control. However, none of the insecticides gave standard level of reduction (80%) of whitefly population. The results of the study revealed that all the insecticides significantly reduced whitefly population infesting blackgram.

However, Thiamethoxam was the most effective insecticide against whitefly and Spinosad was second effective insecticides but Emamectin Benzoate, Lufeneuron and Matrine were less effective insecticides. Neem seed kernel was poorly effective against whitefly infesting blackgram in field condition. The order of effectiveness is Thiamethoxam>Spinosad>Emamectin Benzoate > Lufeneuron>Marine>Neem Seed Kernel.

**Table 5: Effect of biorational insecticides on the incidence of whitefly on blackgram**

| Treatment | No. of whitefly 10 leaves Plant$^{-1}$ | % Reduction over control |
|---|---|---|
| $T_1$ | 5.00 f | 63.17 b |
| $T_2$ | 6.07 e | 55.19 c |
| $T_3$ | 7.03 d | 48.02 d |
| $T_4$ | 8.00 c | 40.91 e |
| $T_5$ | 4.03 g | 70.16 a |
| $T_6$ | 8.97 b | 33.77 f |
| $T_7$ | 13.60 a | ------------- |
| SE | 0.271 | 1.247 |
| CV (%) | 6.24 | 4.16 |
| $LSD_{(0.05)}$ | 0.8355 | 3.9294 |

$T_1$: Spinosad @0.5 ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water

$T_5$: Thiamethoxam 20 WG @0.5 g/l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/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 Stemfly infestation on blackgram different treatment

The average population of stemfly in blackgram plant under different treatments has been shown in Table 6. The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. The data (Table 6) express that the lowest number of stemfly (2.10/plant) was observed in $T_1$ (Spinosad)treated plot followed by $T_5$ (Thiamethoxam) treated plot (2.80/plant) and $T_2$ (Emamectin benzoate) treated plot (3.17/plant) having significant difference between them. $T_5$ (Thiamethoxam) treated plot and $T_2$ (Emamectin benzoate) treated plot result are statistically similar and got the common letter. Other insecticides have intermediate number of stemfly. Neem seed kernel extract showed poor results (5.03/plant) in reducing stemfly population. However, the highest number of stemfly (7.70/plant) was found in control plot which was significantly higher than all other treated plots.

Similarly $T_1$ (Spinosad) showed the best performance (72.77%) in reduction of stemfly population over control followed by $T_5$ (Thiamethoxam) treated plot (63.69%) and $T_2$ (Emamectin benzoate) treated plot (58.70%)having significant difference between them. Neem seed kernel extract showed poor results (34.39%) in reducing stemfly population over control. However, none of the insecticides gave standard level of reduction (80%) of stemfly population. The results of the study reveal that all the insecticides significantly reduced stemfly population infesting blackgram.

However Spinosadwas the most effective insecticide against stemfly and Thiamethoxam was second effective insecticides but Emamectin Benzoate, Lufeneuron and Matrine were less effective insecticides. Neem seed kernel was poorly effective against stemfly infesting blackgram in field condition. The order of effectiveness is

Spinosad>Thiamethoxam> Emamectin Benzoate > Lufeneuron>Marine>Neem Seed Kernel.

**Table 6: Effect of biorational insecticides on the incidence of stemfly on blackgram**

| Treatment | Stemfly Infested plant | % Reduction over control |
|---|---|---|
| $T_1$ | 2.10 f | 72.77 a |
| $T_2$ | 3.17 e | 58.70 b |
| $T_3$ | 3.80 d | 50.39 c |
| $T_4$ | 4.47 c | 41.95 d |
| $T_5$ | 2.80 e | 63.69 b |
| $T_6$ | 5.03 b | 34.39 e |
| $T_7$ | 7.70 a | --------- |
| SE | 0.171 | 2.279 |
| CV (%) | 7.12 | 7.36 |
| $LSD_{(0.05)}$ | 0.2412 | 7.1808 |

$T_1$: Spinosad @0.5ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water

$T_5$: Thiamethoxam @o.5g/l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/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

### 4.5 Incidence of stink bug on blackgram plant

The average population of stink bug in blackgram under different treatments has been shown in Table 7. The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. The data (Table 7) express that the lowest number of stink bug (1.10/plant) was observed in $T_1$ (Spinosad) treated plot followed by $T_2$ (Emamectin benzoate) treated plot (1.63/plant) having significant difference between them. Other insecticides have intermediate number of stink bug. Neem seed kernel extract showed poor results (3.70/plant) in reducing stink bug population. However, the highest number of stink bug (4.33/plant) was found in control plot which was significantly higher than all other treated plots.

Similarly $T_1$ (Spinosad) showed the best performance (74.63%) in reduction of stink bug population over control followed by $T_2$ (Emamectin Benzoate) treated plot (62.41%)having significant difference between them. Neem seed kernel extract showed poor results (14.26%) in reducing stink bug population over control. However, none of the insecticides gave standard level of reduction (80%) of stink bug population. The results of the study reveal that all the insecticides significantly reduced stink bug population infesting blackgram.

However Spinosad was the most effective insecticide against stink bug and Emamectin Benzoate was second effective insecticides but, Thiamethoxam, LufeneuronandMatrine were less effective insecticides. Neem seed kernel was poorly effective against stink bug infesting blackgram in field condition. The order of effectiveness is Spinosad>Emamectin Benzoate >Thiamethoxam> Lufeneuron>Marine> Neem Seed Kernel.

**4.6 Incidence of jassid on blackgram plant**

The average population of jassid in blackgram under different treatments has been shown in Table 7. The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. The data (Table 7) express that the lowest number of jassid (1.07/plant) was observed in $T_1$ (Spinosad) treated plot followed by $T_5$ (Thiamethoxam) treated plot (1.53/plant) having significant difference between them. Other insecticides have intermediate number of jassid. Neem seed kernel extract showed poor results (2.70/plant) in reducing jassid population. However, the highest number of jassid (4.33/plant) was found in control plot which was significantly higher than all other treated plots.

Similarly $T_1$ (Spinosad) showed the best performance (75.30%) in reduction of jassid population over control followed by $T_5$ (Thiamethoxam) treated plot (64.44%)having significant difference between them. Neem seed kernel extract showed poor results (37.45%) in reducing jassid population over control. However, none of the insecticides gave standard level of reduction (80%) of jassid population. The results of the study reveal that all the insecticides significantly reduced jassid population infesting blackgram.

However Spinosad was the most effective insecticide against jassid and Thiamethoxam was second effective insecticides but Emamectin Benzoate, Matrineand Lufeneuron were less effective insecticides. Neem seed kernel was poorly effective against jassid infesting blackgram in field condition. The order of effectiveness is Spinosad>Thiamethoxam> Emamectin Benzoate > Marine>Neem Seed Kernel > Lufeneuron.

**Table 7: Effect of biorational insecticides on the incidence of stink bug and jassid on blackgram**

| Treatment | No. of stink bug plant$^{-1}$ | Reduction Over Control (%) | No. of Jassid 10 leaves plant$^{-1}$ | Reduction Over Control (%) |
|---|---|---|---|---|
| $T_1$ | 1.10 g | 74.63 a | 1.07 g | 75.30 a |
| $T_2$ | 1.63 f | 62.41 b | 1.90 e | 55.91 c |
| $T_3$ | 2.67 d | 38.24 d | 3.20 b | 25.95 f |
| $T_4$ | 3.17 c | 26.76 e | 2.37 d | 45.19 d |
| $T_5$ | 2.13 e | 50.83 c | 1.53 f | 64.44 b |
| $T_6$ | 3.70 b | 14.26 f | 2.70 c | 37.45 e |
| $T_7$ | 4.33 a | ---------- | 4.33 a | ---------- |
| SE | 0.126 | 3.348 | 0.095 | 1.12 |
| CV (%) | 8.14 | 13.02 | 6.72 | 3.82 |
| $LSD_{(0.05)}$ | 0.3876 | 10.548 | 0.2922 | 3.528 |

$T_1$: Spinosad @0.5 ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water

$T_5$: Thiamethoxam @0.5 g/l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/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

### 4.7 Incidence of flea beetle

The average population of flea beetle in blackgram under different treatments has been shown in Table 8. The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. The data (Table 8) express that the lowest number of flea beetle (2.30/plant) was observed in $T_1$ (Spinosad) treated plot followed by $T_5$ (Thiamethoxam) treated plot (2.97/plant) having significant difference between them. Other insecticides have intermediate number of flea beetle.Neem seed kernel extract showed poor results (5.60/plant) in reducing flea beetle population. However, the highest number of flea beetle (9.40/plant) was found in control plot which was significantly higher than all other treated plots.

Similarly $T_1$ (Spinosad) showed the best performance (75.58%) in reduction of flea beetle population over control followed by $T_5$ (Thiamethoxam) treated plot (68.44%)having significant difference between them. Neem seed kernel extract showed poor results (40.38%) in reducing flea beetle population over control. However, only none of the insecticides gave standard level of reduction (80%) of flea beetle population. The results of the study revealed that all the insecticides significantly reduced flea beetle population infesting blackgram.

However, Spinosad was the most effective insecticide against flea beetle and Thiamethoxam was second effective insecticides but Lufeneuron, Emamectin Benzoateand Matrine were less effective insecticides. Neem seed kernel was poorly effective against flea beetle infesting blackgram in field condition. The order of effectiveness is Spinosad>Thiamethoxam>Lufeneuron>Emamectin Benzoate > Marine> Neem Seed Kernel.

### 4.8 Incidence of Flea beetle infested leaf on blackgram

The average number of flea beetle infested leaf in blackgram under different treatments has been shown in Table 8. The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. The data (Table 8) express that the lowest number of flea beetle infested leaf (2.00/plant) was observed in $T_1$ (Spinosad) treated plot followed by $T_5$ (Thiamethoxam) treated plot (2.63/plant) having significant difference between them. Other insecticides have intermediate number of flea beetle infested leaf. Neem seed kernel extract showed poor results (5.74/plant) in reducing flea beetle infested leaf number. However, the highest number of flea beetle infested leaf (9.90/plant) was found in control plot which was significantly higher than all other treated plots.

Similarly $T_1$ (Spinosad) showed the best performance (79.87%) in reduction of flea beetle infested leaf number over control followed by $T_5$ (Thiamethoxam) treated plot (73.32%)having significant difference between them. Neem seed kernel extract showed poor results (44.67%) in reducing flea beetle infested leaf number over control. However, none of the insecticides gave standard level of reduction (80%) of flea beetle infested leaf number over control. The results of the study reveal that all the insecticides significantly reduced number of flea beetle infested leaf infesting blackgram.

However Spinosad was the most effective insecticide against flea beetle infested leaf and Thiamethoxam was second effective insecticides but Emamectin Benzoate, Lufeneuronand, Matrine were less effective insecticides. Neem seed kernel was poorly effective against flea beetle infested leaf infesting blackgram in field condition. The order of effectiveness is Spinosad>Thiamethoxam> Emamectin Benzoate >Lufeneuron>Marine> Neem Seed Kernel.

**Table 8: Effect of biorational insecticides on the incidence of flea bettle and flea beetle infested leaf per plant on blackgram**

| Treatment | No. of flea beetle plant$^{-1}$ | Reduction Over Control (%) | Flea beetle infested leaf plant$^{-1}$ | Reduction Over Control (%) |
|---|---|---|---|---|
| $T_1$ | 2.30 g | 75.58 a | 2.00 g | 79.87 a |
| $T_2$ | 4.27 d | 54.70 d | 3.33 e | 66.30 c |
| $T_3$ | 3.60 e | 61.72 c | 3.97 d | 59.91 d |
| $T_4$ | 4.93 c | 47.44 e | 4.70 c | 52.49 e |
| $T_5$ | 2.97 f | 68.44 b | 2.63 f | 73.32 b |
| $T_6$ | 5.60 b | 40.38 f | 5.47 b | 44.67 f |
| $T_7$ | 9.40 a | ------ | 9.90 a | --------- |
| SE | 0.162 | 1.9163 | 0.19 | 1.703 |
| CV (%) | 5.94 | 5.72 | 7.43 | 4.7 |
| $LSD_{(0.05)}$ | 0.4992 | 6.0383 | 0.5268 | 5.3663 |

$T_1$: Spinosad @0.5 ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2 g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water

$T_5$: Thiamethoxam @0.5 g/l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/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 early pod development stage**

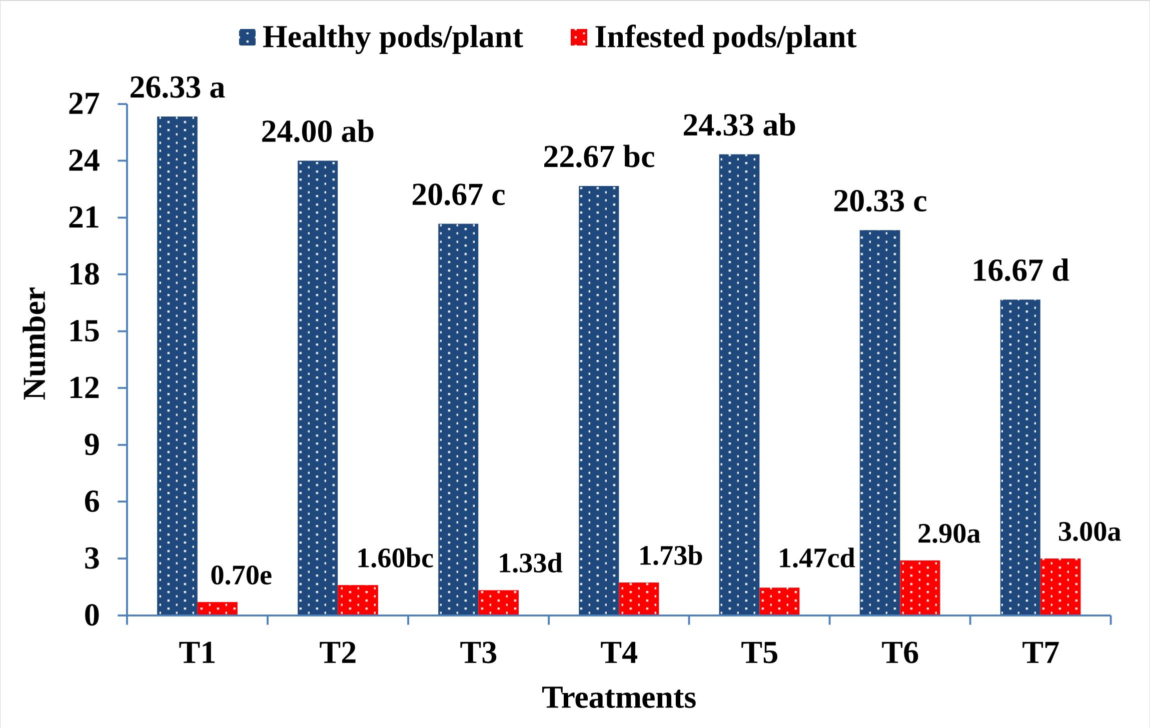
Figure 3 showed the number of healthy pods and infested pods and figure 4 showed the percent infestation of blackgram pod statistically significant differences at early pod development stage for different treatments. The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. In figure 1, the highest number of healthy pod (26.33/plant) was observed in $T_1$ (Spinosad) treated plot which is statistically identical with$T_5$ (Thiamethoxam) treated plot (24.33/plant) and $T_2$ (Emamectin benzoate) treated plot (24.00/plant) respectively and followed by $T_4$ (Matrine) treated plot (22.67/plant). Other insecticides have intermediate number of healthy pods.Neem seed kernel extract treated plot (20.33/plant) and Lufeneurontreated plot (20.67/plant) showed poor results in increasing healthy pod number. However, the lowest number of healthy pod (16.67/plant) was found in control plot which was significantly lower than all other treated plots.

The lowest number of infested pod (0.70/plant) was observed in $T_1$ (Spinosad) treated plot which is statistically different with$T_3$ (Lufeneuron) treated plot (1.33/plant) and $T_5$ (Thiamethoxam) treated plot (1.47/plant). Other insecticides have intermediate number of infested pods.Neem seed kernel extract treated plot (2.90/plant) showed poor results in reducing infested pod number. However, the highest number of infested pod (3.00/plant) was found in control plot which was significantly higher than all other treated plots.

In figure 4, the lowest percentage of infested pod (2.59%) was observed in $T_1$ (Spinosad) treated plot which is statistically different with$T_5$ (Thiamethoxam) treated plot (5.75%), $T_2$ (Emamectin benzoate) treated plot (6.25%), $T_3$ (Lufeneuron) treated plot (6.30%) and $T_4$ (Matrine) treated plot (7.12%). Other insecticides have intermediate percentage of infested pod. Neem seed kernel extract treated plot (12.62%) showed poor results in reducing percentage of infested pod. However, the highest percentage of infested pod (15.60%) was found in control plot which was significantly higher than all other treated plots.

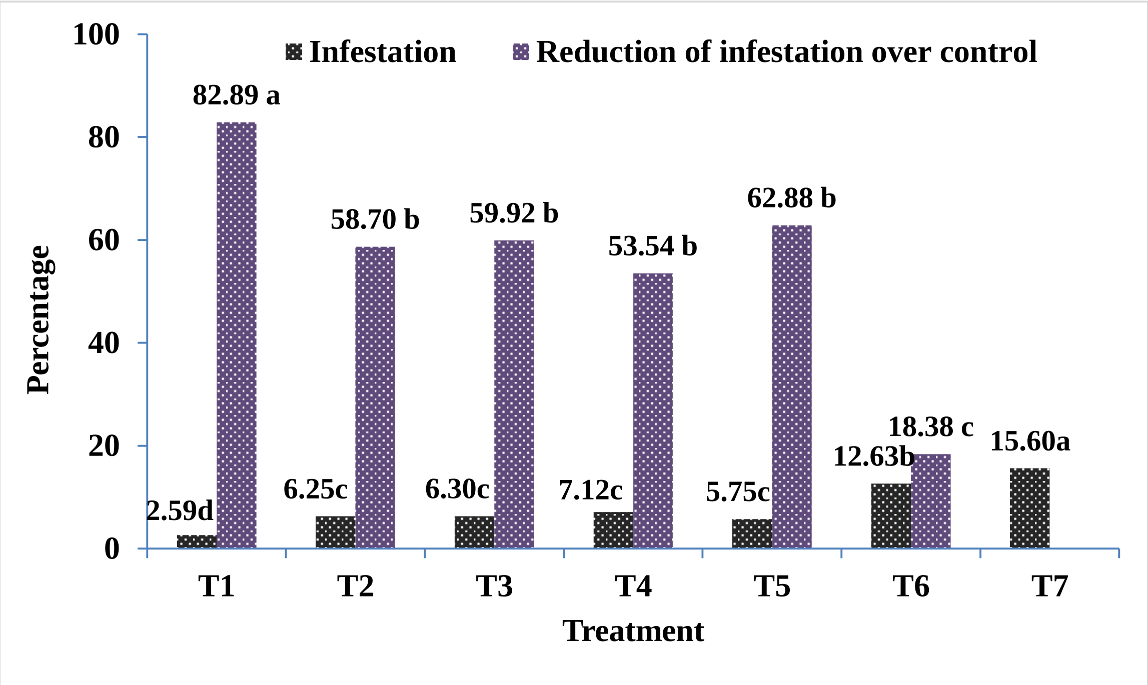
Similarly $T_1$ (Spinosad) showed the best performance (82.89%) in reduction of infestation over control followed by $T_5$ (Thiamethoxam) treated plot (62.88%), $T_3$ (Lufeneuron) treated plot (59.92%), $T_2$ (Emamectin benzoate) treated plot (58.70%) and $T_4$ (Matrine) treated plot (53.54%)having significant difference between them. Neem seed kernel extract showed poor results (18.38%) in reduction of infestation over control. However, only spinosad insecticide gave standard level of reduction (80%) of infestation over control. The results of the study revealed that all the insecticides significantly reduced percentage of infestation of blackgram pods.

However Spinosad was the most effective insecticide against pod borer infestation but Thiamethoxam, Emamectin Benzoate, Lufeneuronand Matrine were less effective insecticides. Neem seed kernel was poorly effective against pod borer infestation in field condition. The order of effectiveness is Spinosad> Thiamethoxam> Lufeneuron> Emamectin Benzoate > Marine> Neem Seed Kernel.




$T_1$ = Spinosad $T_2$ = Emamectin Benzoate $T_3$ = Lufeneuron $T_4$= Matrine
$T_5$ = Thiamethoxam $T_6$ = Neem Seed Kernel $T_7$= Control

Figure 3. Effect of different treatments on infestation and reduction over control percentage of pod borer attacking blackgram at early pod development stage




$T_1$ = Spinosad $T_2$ = Emamectin Benzoate $T_3$ = Lufeneuron $T_4$= Matrine
$T_5$ = Thiamethoxam $T_6$ = Neem Seed Kernel $T_7$= Control

Figure 4. Effect of different treatments on infestation and reduction over control percentage of pod borer attacking blackgram at early pod development stage

### 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 pest management practices (Table 9). The mean performance of the treatment having the common letter is identical & those having the different letter are statistically different from each other. In table 9, the highest number of healthy pod (57.67/plant) was observed in $T_1$ (Spinosad) treated plot which is statistically identical with$T_5$ (Thiamethoxam) treated plot (51.33/plant) respectively and followed by $T_2$ (Emamectin benzoate) treated plot (50.33/plant) having significant difference between them. Other insecticides have intermediate number of healthy pods. Neem seed kernel extract treated plot (43.33/plant) showed poor results in increasing healthy pod number. However, the lowest number of healthy pod (38.33/plant) was found in control plot which was significantly lower than all other treated plots.

The lowest number of infested pod (1.90/plant) was observed in $T_1$ (Spinosad) treated plot which is statistically different with $T_5$ (Thiamethoxam) treated plot (2.40/plant), $T_3$ (Lufeneuron) treated plot (2.63/plant) and $T_2$ (Emamectin benzoate) treated plot (2.67/plant). Other insecticides have intermediate number of infested pods. Neem seed kernel extract treated plot (3.60/plant) showed poor results in reducing infested pod number. However, the highest number of infested pod (6.33/plant) was found in control plot which was significantly higher than all other treated plots.

The lowest percentage of infested pod (3.31%) was observed in $T_1$ (Spinosad) treated plot which is statistically different with$T_5$ (Thiamethoxam) treated plot (4.47%) and $T_2$ (Emamectin benzoate) treated plot (5.03%). Other insecticides have intermediate percentage of infested pods. Neem seed kernel extract treated plot (7.66%) showed poor results in reducing percentage of infested pod. However, the highest percentage of infested pod (14.19%) was found in control plot which was significantly higher than all other treated plots.

Similarly $T_1$ (Spinosad) showed the best performance (76.67%) in reduction of infestation over control followed by $T_5$ (Thiamethoxam) treated plot (68.55%), $T_2$ (Emamectin benzoate) treated plot (64.56%) and $T_3$(Lufeneuron) treated plot (61.40%)having significant difference between them. Neem seed kernel extract showed poor results (45.94%) in reduction of infestation over control. However, none of the insecticide gave standard level of reduction (80%) of infestation over control. The results of the study revealed that all the insecticides significantly reduced percentage of infestation of blackgram pods.

However, Spinosad was the most effective insecticide against pod borer infestation but Thiamethoxam, Emamectin benzoate, Lufeneuron and Matrine were less effective insecticides. Neem seed kernel was poorly effective against pod borer infestation in field condition. The order of effectiveness is Spinosad> Thiamethoxam> Emamectin Benzoate> Lufeneuron> Neem Seed Kernel> Marine.

**Table 9. Effect of different treatments on the infestation of pod borer on blackgram at late pod development stage**

| Treatment | Healthy pods $plant^{-1}$ (No.) | Infested pods $plant^{-1}$ (No.) | Infestation (%) | Reduction of infestation over control (%) |
|---|---|---|---|---|
| $T_1$ | 55.67 a | 1.90 e | 3.31 f | 76.67 a |
| $T_2$ | 50.33 b | 2.67 d | 5.03 de | 64.56 b |
| $T_3$ | 45.67 c | 2.63 d | 5.47 d | 61.40 b |
| $T_4$ | 40.33 de | 4.50 b | 10.04 b | 29.16 d |
| $T_5$ | 51.33 ab | 2.40 d | 4.47 e | 68.55 b |
| $T_6$ | 43.33 cd | 3.60 c | 7.66 c | 45.94 c |
| $T_7$ | 38.33 e | 6.33 a | 14.19 a | --------- |
| SE | 1.3403 | 0.1503 | 0.2926 | 2.2268 |
| CV (%) | 5.00 | 7.58 | 7.07 | 6.68 |
| $LSD_{(0.05)}$ | 4.1298 | 0.4631 | 0.9015 | 7.0168 |

$T_1$: Spinosad @0.5 ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2 g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water

$T_5$: Thiamethoxam @0.5 g/l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/l of water at 10 days interval

$T_7$: Untreated control

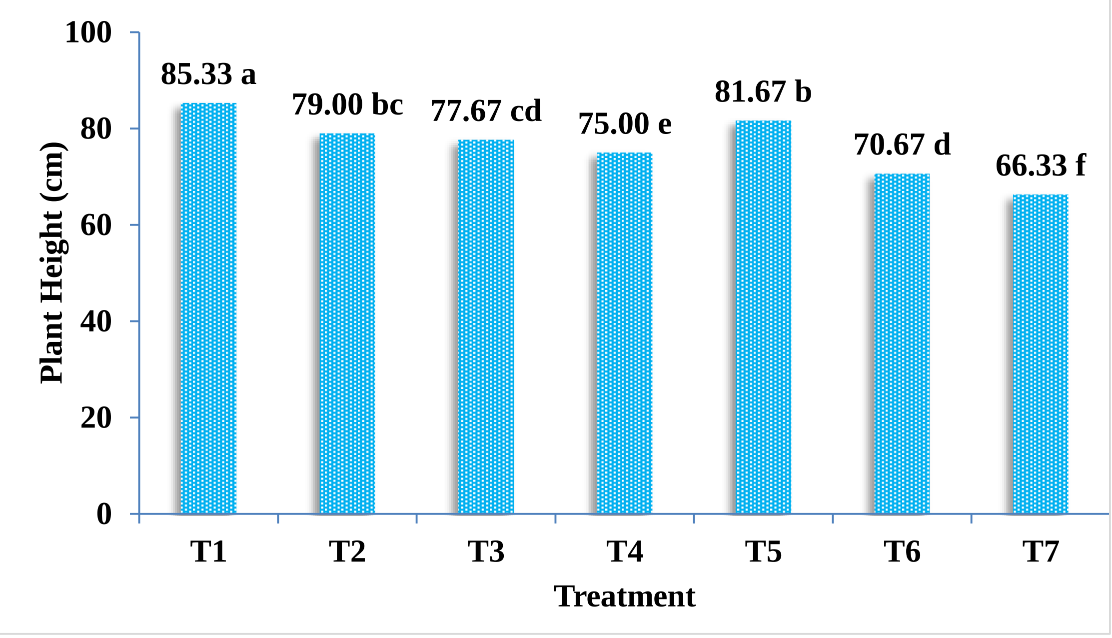
In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

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 Effect of biorational insecticides on yield of blackgram

#### 4.11.1 Plant height

Plant height was significantly affected by the application of chemical insecticides and botanical extracts. Among the treatments, the tallest plant (85.33 cm) was observed in Spinosad application with is statistically different than Thiamethoxam application (81.67 cm) and Emamectin benzoate application (79.00 cm). On the other hand, the shortest plant (66.33 cm) was recorded from control (Fig. 5).

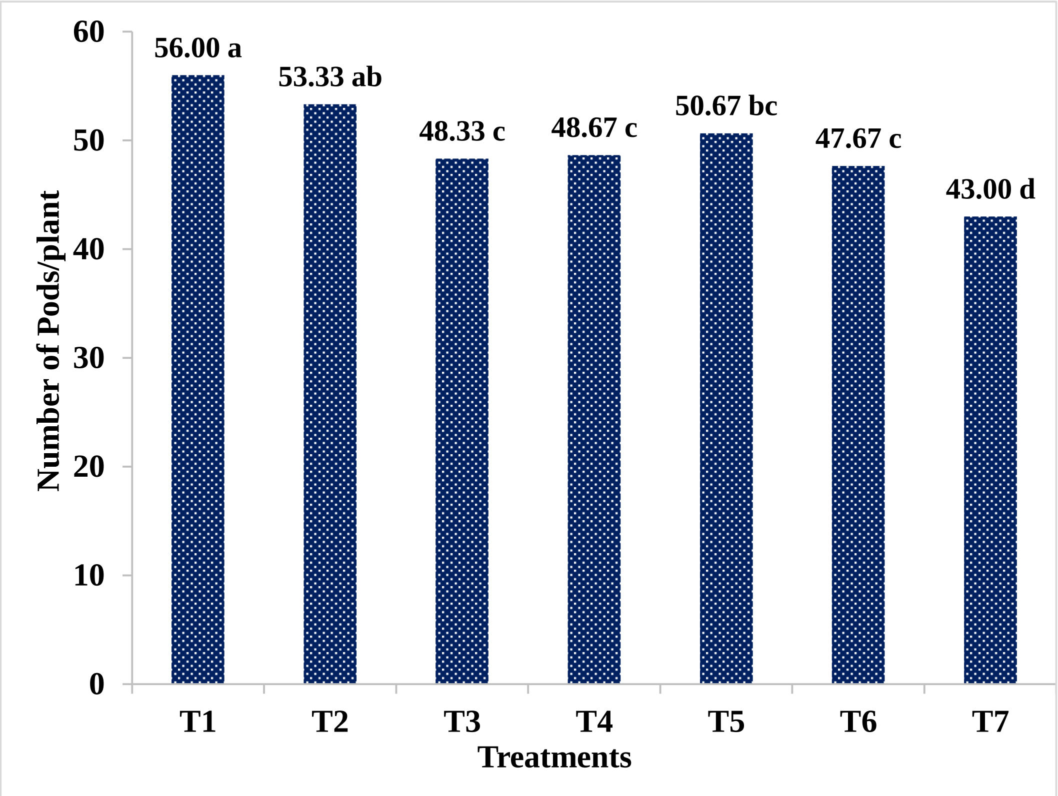



$T_1$ = Spinosad $T_2$ = Emamectin Benzoate $T_3$ = Lufeneuron $T_4$= Matrine
$T_5$ = Thiamethoxam $T_6$ = Neem Seed Kernel $T_7$= Control

Figure 5. Effect of biorational insecticides on the height of blackgram plant.

#### 4.11.2 Number of pods plant$^{-1}$

Number of pods plant$^{-1}$ was significantly influenced by the effect of various chemical insecticides and botanical extract whereas, treatment Spinosad produced the maximum number of pods plant$^{-1}$ (56.00) and it was statistically similar to emamectin benzoate (53.33) where the maximum reduction of insects was taken. Among the other treatments, the minimum number of pods plant$^{-1}$ (43.00) was recorded in untreated or control treatment (Figure 6).These results agree with the reports of several researchers Jahangir Shah et al. (2007) who reported that pods/plant and seed yield kg $ha^{-1}$ varied significantly among different insecticides.




$T_1$ = Spinosad $T_2$ = Emamectin Benzoate $T_3$ = Lufeneuron $T_4$= Matrine
$T_5$ = Thiamethoxam $T_6$ = Neem Seed Kernel $T_7$= Control

Figure 6. Effect of biorational insecticides on number of pods/plant on blackgram

**4.11.3 Pod length (cm)**

Table 10 showed the pod length was significantly affected by the different chemical insecticides and botanical management of insect pests on blackgram plant. Among the treatment, spinosad produced the longest pod (5.78 cm) which was statistically different than Thiamethoxam (5.23 cm) and Emamectin benzoate (5.02cm). On the other hand, the shortest pod (3.42 cm) was recorded in control or untreated treatment. Rest of the treatments showed the statistically more or less similar results.

Similarly $T_1$ (Spinosad) showed the best performance (69.15%) in increasing pod length over control followed by $T_5$ (Thiamethoxam) treated plot (52.98%) and $T_2$ (Emamectin benzoate) treated pod (46.77%) having significant difference between them. Neem seed kernel extract showed poor results (31.96%) with was statistically identical with Matrine treated plot (25.80%) in increasing pod length over control.

**Table 10. Effect of biorational insecticides to manage the insect pests and its impact on yield contributing character of blackgram**

| Treatment | Pod length (cm) | Increase over control (%) |
|---|---|---|
| $T_1$ | 5.78 a | 69.15 a |
| $T_2$ | 5.02 bc | 46.77 bc |
| $T_3$ | 4.70 cd | 37.53 cd |
| $T_4$ | 4.30 e | 25.80 e |
| $T_5$ | 5.23 b | 52.98 b |
| $T_6$ | 4.51 de | 31.96 de |
| $T_7$ | 3.42 f | -------- |
| SE | 0.095 | 3.0529 |
| CV (%) | 3.5 | 12.01 |
| LSD $_{(0.05)}$ | 0.29 | 9.6197 |

$T_1$: Spinosad @0.5 ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2 g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water + 4g detergent

$T_5$: Thiamethoxam @0.5 g/l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/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.

### 4.11.4 Number of seed pod$^{-1}$

Number of seed/pod was significantly affected by the different chemical insecticides and botanical management of insect pests on blackgram plant. Among the treatment, Spinosad produced the highest number of seed pod$^{-1}$ (8.02) which was statistically different from Emamectin benzoate treated plot (7.30). On the other hand, the lowest (4.02) was recorded in control or untreated treatment which was statistically different to all other treated plot. Rest of the treatments showed the statistically more or less similar results.

Similarly $T_1$ (Spinosad) showed the best performance (99.69%) in increasing number of seed over control followed by $T_2$ (Emamectin benzoate) treated plot (81.98%)having significant difference between them. Neem seed kernel extract showed poor results (25.54%) which was statistically identical with Matrine treated plot (19.05%) in increasing number of seed/pod over control.

### 4.11.5 1000 seed weight

Table 11 showed 1000 seed weight was significantly affected by the different management practices of insect pests on blackgram plant. Among the treatment, Spinosad produced the highest weight (35.50 g) which was statistically differentthan Thiamethoxam treated plot (32.20 g). On the other hand, the lowest (23.26 g) was recorded in control or untreated treatment which was statistically different than all other treated plot. Rest of the treatments showed the statistically more or less similar results. Similarly $T_1$ (Spinosad) showed the best performance (52.65%) in increasing 1000 seed weight over control followed by $T_5$ (Thiamethoxam) treated plot (38.45%) having significant difference between them. Neem seed kernel extract showed poor results

(10.00%) which was statistically identical with Matrine treated plot (6.33%) in increasing number of seed/pod over control.

### 4.11.6 Yield

Yield was significantly affected by the different management practices of insect pests on blackgram plant (Table 11). Among the treatment, Spinosad produced the highest yield (1.84 t/ha) which was statistically different from all other treated plot. On the other hand, the lowest yield (1.16 t/ha) was recorded in untreated control treatment which was also statistically different from all other treated plot. Rest of the treatments showed the statistically more or less similar results.

Similarly $T_1$ (Spinosad) showed the best performance (60.65%) in increasing yield followed by $T_5$ (Thiamethoxam) treated plot (44.59%), $T_2$ (Emamectin benzoate) treated plot (44.32%)and $T_3$ (Lufeneuron) applied plot (40.76%) having significant difference between them. Neem seed kernel extract showed poor results (31.90%) in increasing yield over control.

**Table 11. Effect of biorational insecticides to manage the insect pests and its impact on yield characteristics of blackgram**

| Treatment | Number of seed $pod^{-1}$ | Increase over control (%) | 1000 seed weight (g) | Increase over control (%) | Yield (t/ha) | Increase over control (%) |
|---|---|---|---|---|---|---|
| $T_1$ | 8.02 a | 99.69 a | 35.50 a | 52.65 a | 1.84 a | 60.65 a |
| $T_2$ | 7.30 b | 81.98 b | 30.78 c | 32.35 c | 1.65 b | 44.32 b |
| $T_3$ | 6.47 c | 61.14 c | 29.80 d | 28.14 d | 1.61 b | 40.76 bc |
| $T_4$ | 4.78 d | 19.05 d | 24.73 e | 6.33 e | 1.58 b | 38.06 bc |
| $T_5$ | 6.55 c | 63.06 c | 32.20 b | 38.45 b | 1.66 b | 44.59 b |
| $T_6$ | 5.03 d | 25.54 d | 25.58 e | 10.00 e | 1.50 b | 31.90 c |
| $T_7$ | 4.02 e | -------- | 23.26 f | -------- | 1.16 c | ----- |
| SE | 0.1633 | 3.9983 | 0.2756 | 1.1993 | 0.0489 | 2.7784 |
| CV (%) | 4.55 | 11.86 | 1.66 | 7.42 | 5.38 | 11.09 |
| LSD $_{(0.05)}$ | 0.4883 | 12.583 | 0.8491 | 3.779 | 0.1506 | 8.7548 |

$T_1$: Spinosad @0.5ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @ 0.2 g/l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water

$T_5$: Thiamethoxam @o.5g/l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/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. 2,12,500 ha$^{-1}$ was obtained in $T_1$treatment and the second highest was found Tk. 1,92,300 ha$^{-1}$ in $T_5$(Table 12). The highest benefit cost ratio (2.31) was estimated for $T_1$treatment and the lowest (1.28) for $T_4$ treatment under the trial. The highest BCR (Benefit cost ratio) was found in the treatment $T_1$might be due to the minimum pest infestation compared to other treatments and the highest yield of this treatment.

**Table 12: Benefit cost ratio for the production of blackgram due to different Treatments**

| Treatment | Cost of pest management (Tk.) | Yield (t/ha) | Gross return (Tk.) | Net return (Tk.) | Adjusted net return (Tk.) | Benefit cost ratio |
|---|---|---|---|---|---|---|
| $T_1$ | 26700 | 1.84 | 239200 | 212500 | 61700 | 2.31 |
| $T_2$ | 25900 | 1.65 | 214500 | 188600 | 37800 | 1.46 |
| $T_3$ | 23100 | 1.61 | 209300 | 186200 | 35400 | 1.53 |
| $T_4$ | 23900 | 1.58 | 205400 | 181500 | 30700 | 1.28 |
| $T_5$ | 23500 | 1.66 | 215800 | 192300 | 41500 | 1.77 |
| $T_6$ | 17300 | 1.5 | 195000 | 177700 | 26900 | 1.55 |
| $T_7$ | 0 | 1.16 | 150800 | 150800 | ----- | ------ |

**Price of Blackgram@ 130 taka/kg**

$T_1$: Spinosad @0.5ml/l of water at 10 days interval

$T_2$: Emamectin Benzoate @1.0 ml/l of water at 10 days interval

$T_3$: Lufeneuron @0.2g /l of water at 10 days interval

$T_4$: Matrine @1 ml/l of water

$T_5$: Thiamethoxam @0.5g /l of water at 10 days interval

$T_6$: Neem seed kernel @5 g/l of water at 10 days interval

$T_7$: Untreated control

# CHAPTER V

## SUMMARY AND CONCLUSION

The present study was conducted at the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from September to November, 2019 for biorational management of major insect pests of blackgram. The experiment comprised of seven treatments viz. $T_1$= Spinosad @0.5 ml/l of water at 10 days interval, $T_2$=Emamectin Benzoate @1.0 ml/l of water at 10 days interval, $T_3$= Lufeneuron @0.2 g/l of water at 10 days interval, $T_4$= Matrine @1 ml/l of water, $T_5$= Thiamethoxam @0.5 ml/l of water at 10 days interval, $T_6$= Neem seed kernel @5 g/l of water and $T_7$= Untreated control. Blackgram variety BARI mash-3 was grown as experimental material to evaluate the treatment on insect pests. The experiment was laid out in randomized complete block design (RCBD) with four replications. Population of all insects was increased with plant age and aphid, whitefly and stemfly populations reached maximum at 7th week, but in case of flea beetle it was at 5$^{th}$ week, jassid was at 3$^{rd}$ week and in pod borer it was at 9$^{th}$ week after germination and then declined with plant age.  Aphid was the most abundant insects among all other pests. All the treatments had significant effect against insect pests attacking blackgram and reduced their population. However, Spinosad @0.5 ml/l of water at 10 days interval treatment was most effective against all of the insects in terms of number and percent reduction of insect pests. It reduced 80.05% aphid, 63.17% whitefly,72.77% stemfly, 74.63% stink bug, 75.30% jassid, 78.58% flea beetle, 79.87% infested leaf, 82.39% pod borer infestation at early stage and 76.67% pod borer attack at late pod development stage. Thiamethoxam showed almost similar performance in reduction of insect population over control.

Neem seed kernel @5 g/l of water at 10 days interval treatment was less effective against most of the insects in terms of number of insects and percent reduction of insect pests but it showed better performance than some of the chemical insecticide treatment. It reduced 63.31% aphid, 33.7% whitefly,34.39% stemfly infestation, 14.26% stink bug, 75.30% jassid, 40.38% flea beetle, 44.67% flea beetle infested leaf, 18.38% pod borer infestation at early stage and 45.94% pod borer attack at late pod development stage.

Spraying of biorational insecticides significantly influenced on growth characteristics of blackgram. The tallest plant (85.33 cm) were found from spinosad. Correspondingly, untreated treatment produced the shortest plant (66.33 cm). Yield and yield contributing characters also showed significant difference due to the effect of various treatments. However, Spinosad @0.5 ml/l of water at 10 days interval the greater results on whole yield and yield contributing characteristic viz. number of pods plant$^{-1}$ (56.00), pod length (5.78 cm), number of seeds pod$^{-1}$ (8.02), 1000 seed weight (35.50 g) and yield (1.84 t/ha). On the other hand, the minimum number of pods plant$^{-1}$(43.00), shortest pod (3.42 cm), minimum number of seeds pod$^{-1}$(4.02), lowest 1000 seed weight (23.26 g) and minimum yield (1.16 t/ha) were obtained in control treatment.

The results of economic analysis of blackgram cultivation showed that the highest net return of Tk. 212500 ha$^{-1}$ and adjusted net return of Tk. 61700 ha$^{-1}$ was obtained in Spinosad treatment. The highest benefit cost ratio (2.31) was estimated for Spinosad treatment and the lowest (1.28) for Matrine treatment. Benefit cost ratio of neem seed kernel extract was 1.55 which was much better than some other insecticide treatment.

## Conclusion

Major insect pest was found aphid, white fly, stemfly, jassid, flea beetle, stink bug and pod borer. From the above results, it could be concluded that among the all applied treatments, Spinosad showed the superior performance on managing the insect pests as well as growth and yield characteristics of blackgram. Thiamethoxam showed almost similar performance and plant products gave poor results for the management of insects of blackgram. Neem seed kernel extract showed better performance in some parameter compared to some insecticides.

## Recommendations

The following recommendations may be suggested:

1. Further study may be conducted to ensure the pest incidence on blackgram and its impact on the growth and yield performance.
2. More chemicals and botanical extracts should be included for future study as sole or different combinations to ascertain the better performance.

# REFERENCES


Afzal, M.A., Bakr, A.M. and Rahman, M.L. (1999). Cultivation of Blackgram in Bangladesh. (Booklet in bangla). LBMDPP. Bangladesh Agricultural Research Institute (BARI), Joydepbpur, Gazipur.

Ahmed, Z.U., Shaikh, M.A.Q., Khan, A.I. and Kaul, A.K. (1978). Evaluation of local, exotic and mutant germplasm of Blackgram for varietal characters and yield in Bangladesh. *Sabraoj*. **10**: 48-49.

Alice, J., Sujeetha, R.P., Muthurani, N.and Nadarajan, L. (2007). Effect of indigenous plant products and oils against the pulse beetle *Callosobruchus chinensis* (Linn.) on stored black gram. *Asian J. Bio Sci.* **2**(1/2): 203-204.

Bakr, M.A., Afzal, M.A., Hamid, A., Haque, M.M. and Aktar, M.S. (2004). Blackgram in Bangladesh. Lentil, Blackgram and Mungbean Development Pilot Project, Publication No.25, Pulse Research Centre, BARI, Gazipur, Bangladesh. 60pp.

BARI (Bangladesh Agricultural Research Institute). (1984). Coordinated Scheme for the Improvement of Mashkalai and Khesari (Insect Pests), Annual Report 1983/84. Joydebpur, Gazipur, Bangladesh: Entomology Division, BARI. 25pp.

Batra, H.N. (1969). Food plans, bionomics and control of flea beetles. *Indian Farming.* **19**(3): 38-40.

BBS (Bangladesh Bureau of Statistics). (2005). Year Book of Bangladesh. Statistics Division. Ministry of Planning. Government of the Peoples Republic of Bangladesh, Dhaka.

BBS (Bangladesh Bureau of Statistics). (2012). Statistical Year Book of Bangladesh. Statistics Division. Ministry of Planning. Government of the People's Republic of Bangladesh, Dhaka. pp. 141-142.

Bhatt, N.J. and Patel, R.K. (200l). Biology of pod borer, *Helicoverpa armigera. Indian J. Entomol.* **63**(3): 255-259.

Chhabra, K.S. Brar, J.S. and Kooner, B. (1981). Jassid species on recorded on greengram, blackgram and redgram in the Punjab. *Pulse Crops News.* **1**: 65.

DAE (Department of Agricultural Extension). (2019). Pest list of Bangladesh, Ministry of Agriculture, Government of the People's Republic of Bangladesh. Khamarbari, Dhaka.

Elias, S.M., Hossain, M.S., Sikder, F.S., Ahmed, J. and Karim, M.R. (1986). Identification of constraints to pulse production with special reference to present farming system. Annual report of the agriculture Economic division, BARI, Joydebpur. pp. 1-13.

FAO (Food and Agriculture Organization). (2011). Ecocrop database. FAO, Rome, Italy.

Fuller, M.F. (2004). The Encyclopedia of Farm Animal Nutrition. CABI Publishing Series. 606pp.

Godfrey, L. D. and Trumble, J.T. (2009). UC IPM Pest Management Guidelines: Celery. *UC IPM Online*. Retrieved on 2013-01-03.

Gohl, B. (1982). Les aliments dubetail sous les tropiques. FAO, Division de Production et Sante Animale, Rome, Italy.

Gupta, M.P. and Pathak, R.P. (2009). Research Bioefficacy of neem products and insecticides againstthe incidence of whitefly, yellow mosaic virus and pod borer in Black gram. *Natrl. Prod. Radi*. **8**(2): 133.

Gupta, P.K. and Singh, J. (1984). Control of *Ophiomyia phaseoli* Tryon in greengram with granular insecticides. *Indian J. Agril. Sci.* **54**: 321-324.

Haider, M.Z. (1996). Effectiveness of some IPM packages for the management of virus-disseminating whitefly on tomato. M. S. Thesis in Entomology. IPSA. Salna, Gazipur, Bangladesh. pp. 1-65.

Hirano, K., Budiyanto, E. and Winarni, S. (1993). Biological characteristics and forecasting outbreaks of the whitefly *Bemisia tabaci,* a vector of virus diseases in soybean fields. Food and Fertilizer Technology Center. Technical Bulletin. No. 135.

Hossain, A.M. (2015). Efficacy of some insecticides against insect pests of mungbean (*Vigna radiata* L.). *Bangladesh J. Agril. Res*. **40**(4): 657-667.

Hussain, M. (1984). Controlling rice borers under Bangladesh conditions. *Pestology.* **8**(8): 28

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). (1982). Proceedings of the International Work shopon *Heliothis* Management,15-20 November 1981, ICRISAT Center, Patancheru, A.P., India. pp. 418.

Iqbal, J., Nadeem, M., Assi, M.S., Fiaz, M.M. and Hassan, M.W.U. (2015). Comparative efficacy of some insecticides against sucking insect pests on mungbean, *Vigna radiata* (L.) Wilczek. *Gomal University J. Res*. **29**(1): 1-37.

Islam, M., Sarker, N.R. and Islam, M. M. (1995). Effect of feeding legume forage with straw supplementation on milk production at Pabna milk shed area. *Asian-Aust. J. Animal Sci.* **8(**2): 107-111.

Jackson, G. (2015). *Ophiomyia phaseoli* (bean fly) crop protection compendium and from bean fly (*Phyiomyia* sp.). Department of Agriculture and Fisheries. Queensland Government. Information from CABI Australian Museum.

Jansen, P.C.M. (2006). *Vigna mungo* (L.) Hepper. Record from Protabase. Brink, M. and Belay, G. (Eds.). PROTA (Plant Resources of Tropical Africa / Ressourcesvégétales de l'Afriquetropicale), Wageningen, Netherlands.

Jat, S.K. and Rana, B.S. (2018). Occurrence of common aphidophagous natural enemies on blackgram. *J. Entomol. Zool. Stud*. **6**(2): 2716-2719.

Jayaraj, S. (1982). Biological and Ecological Studies of *Heliothis*, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). Proceedings of the International Workshop on *Heliothis* Management. ICRISAT Center, Patancheru, India, 15-20 November 1981. pp. 17-28.

Justin, C.G.L., Anandhi, P. and Jawahar, D. (2015). Management of major insect pests of blackgram under dry land conditions. *J. Entomol. Zool. Stud*. **3**(1): 115-121

Kaul, A. (1982). Pulses in Bangladesh, BARC (Bangladesh Agricultural Research Council), Farmgate, Dhaka, Bangladesh. pp.27.

Khade, K.N., Undirwade, D.B., Tembhurine, R.D. and Landae, G.K. (2014). Biorational management of sucking pests of cowpea *Vigna sinensis* L. *Trends Bio Sci.* **7**(20): 3212-3217.

Khajuria, S., Rai, A.K. and Kumar, K.L.R. (2015). Evaluation of integrated pest management (IPM) module against sucking pests of black gram under semi arid conditions. *Insect Environ.* **20**(4): 126.

Khan, M.A.A. (1981). The effect of $CO_2$ environment on the pattern of growth and development in rice and mustard. Ph.D. thesis. Dissertation. Royal Vet. And Agril. Univ. Copenhagen. 104pp.

Khan, N.A., Ansari, H.R. and Samiullah. (1997). Effect gibberellic acid spray and basal nitogen phosphorus on productivity and fatty acid composition of rapeseed-mustard. *J. Agron. Crop Sci.* **179**: 29-33.

Krishna, K.R. (2010). Agroecosystems of South India: nutrient dynamics, ecology and productivity. Universal-Publishers.

Kumar, C.T.A. and Shivaraju, C. (2009). Evaluation of newer insecticide molecules against pod borers of black gram. *Karnataka J. Agril Sci.* **22**(3): 521-523.

Luckman, W.H. and Metcalf, R.L. (1978). The pest management concept. In: Introduction to Insect Pest Management. John Willey and Sons, New York. pp. 3-35.

Mandal, D., Bhowmik, P., Baral, K. and Chatterjee, M.L. (2013). Field efficacy and economics of some insecticides against spotted pod borer (*Maruca testulalis* Geyer) of black gram. *J. Crop Weed.* **9**(2): 177-180.

Mia, M.D. (1988). Current status of insect research of pulse crops and future research needs. In: Proceedings of the workshop on disease resistance breeding in pulses. Thana central technology transfer and identification project, Dhaka, pp. 87-93.

Nag, N., Sharma, S. K., and Kant, A. (2006). Agronomic evaluation of some induced mutants of urd bean (*Vigna mungo* (L.) Hepper). *SABRAO J. Breed. Gene*. **38**(1): 29-38.

Naresh, J.S. and Nene, Y.L. (1980). Host range, host preference for oviposition and development and the dispersal of *Bemisia tabaci* (Genn). A vector of several plant viruses. *Indian J. Agril. Sci*. **50**: 620-623.

Nikul, K.,Berani, P.,Godhani, H., and Bhatt, N.A. (2018). Bio-efficacy of botanical insecticides against lepidopteran insect pest infesting blackgram. *J. Entomol. Zool. Stud*. **6**(4): 642-646.

Nitharwal, M. (2009). Management of Key Insect Pests of Green Gram, *Vigna radiata* (Linn.) Wilchzek with Special Reference to Biorational Practices. PhD Thesis. Rajasthan Agricultural University, Bikaner.

Panduranga, G.S., Vijayalakshmi, K., Reddy, K. and Loka. (2012). Evaluation of insecticides for management of *Bemisia tabaci* and Mymv disease in mungbean [*Vigna radiata* (L.) Wilczek]. *Annals Plant Protect. Sci*. **19**(2): 295-298.

Parashar, S.M.P. (2006). Post-harvest profile of black gram. MRPC-71, Ministry of agriculture, Directorate of marketing and inspection, India.

Parmar, S.G., Naik, M.M., Pandya, H.V., Rathod, N.K., Patel, S.D., Dave, P.P. and Saiyad, M.M. (2015). Bio-efficacy of some insecticides against pest complex of blackgram [*Vigna mungo* (L.) Hepper]. *Intl. J. Plant Protect.* **8**(1): 162-168.

Parvatha, P. and Reddy. (2016). Sustainable Crop Protection under Protected Cultivation.Indian Institute of Horticultural Research Bangalore, India. pp. 99-108.

Patil, S.K. and Jamadagni, B.M. (2008). Efficacy and economics of some insecticides against pod borers in blackgram. *Annals Plant Protect. Sci.* **16**(2): 347-349.

Phoelman, J.M. (1991). The mungbean, Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi, Bombay and Calcutta, India. 292pp.

Prakash, N.H.,Subhag, S.R., Anuragi, M.K. and Chandramani. (2014). Efficacy of indigenous oils on growth and development of *Callosobruchus chinensis* infesting blackgram. *Annals Plant Protect. Sci.* **22**(2): 283-286

Prodhan, M.Z.H., Maleque, M.A., Kabir, K.H., Zahid, M.A. and Hossain, M.A. (2000). Effect of sowing date and variety on the incidence of stem fly (*Ophiomyia phaseoli* Tryon) in Blackgram. *Bangladesh J. Entomol.* **10**(2): 79-86.

Rabindra, R.J., Ballali, C.R. and Ramanujan, B. (2004). Biological options for insect pests and nematode management in pulses. Kalyani Publishers, New Delhi, India. 487pp.

Rahman, M.M. (1991). Control measures of important insect pests of major pulses. In: Advances in Pulses Research in Bangladesh. Proc. Second National Workshop on Pulses, 6-8 June, 1989, BARI, Joydebpur, Bangladesh. pp. 139-141.

Saxena, H. P. (1983). Losses in black gram due to insect-pests. *Indian J. Entomol*. **2**: 294-297.

Sehgal, V.K. and Ujagir, R. (1988). Insect and pest management of mungbean in India. Proceedings of the 2nd International Symposium. Asian Vegetable Research and Development Centre, Shanhua, Taiwan.

Sehgal, V. K., Khan, M. A., Mahobe, J., Sen, A. K. and Mandal, C.K. (1980). Survey and taxonomic studies on the agromyzid files (Diptera) of north India, with special references to their host plant relationships. Final Report of ICAR Adhoc Reserch Scheme (1977-1980). G.B. Plant University of Agriculture and Technology, Pantnagar, Uttarakhand. 167pp.

Sharma, O.P., Bambawale, O.M., Gopali, J.B., Bhagat, S., Yelshetty, S., Singh, S.K.., Anand, R. and Singh, O.M. (2011). Field guide Mung bean and Urd bean. Government of India, Department of agricultural and co-operation, NCIPM, ICAR, New Delhi, India.

Sharma, S.R. and Dhermendra, P.S. (2015). Competitive studies of insecticides for the control of sucking pests in urdbean (*Vigna mungo*) in relation to *yield. Intl. J. Plant Protect.* **8**(2): 393-396.

Shivaraju, C., Kumar, C.T.A., Sudhirkumar, S. and Thippaiah, M. (2011). Efficacy of indigenous materials and new insecticide molecules against *Maruca testulalis* (Hubner) on blackgram. *Intl. J. Plant Protect*. **4**(1): 214-216.

Singh, A.K., Kumar, P. and Chandra, N. (2013). Studies on yield production of blackgram sown at different planting density. *J. Environ. Bio.* **34**: 1007-1011.

Singh, H. and Singh, G. (1975). Biological studies on *Heliothis armigera* (Hub.) in Punjab. *Indian J. Entomol.* **37**: 154-164.

Singh, O.P. and Singh, K.J. (1990). Seasonal incidence and damage of *Melanagromyza sojae* (Zehntner) on soybean. *Indian J. Plant Protect*. **18**: 271-275.

Singh, S.K., Singh, A.K., Singh, J.P. and Pathak, V. (2018). Effect of Application Schedule of Microbial and Chemical Insecticides on Insect-Pest Control and Grain Yield of Mungbean (*Vigna radiata* (L.) Wilczek). *Intl J. Current Microbio. Appl. Sci*. **7**(9): 1717-1727.

Singh, R.S. and Paras, N. (2011). Effect of biorational approaches on Pigeon pea pod and grain damage by pod bug (*Clavigralla gibbosa* Spinola). *Annals Plant Protect. Sci.* **19**(1): 75-79.

Sonune, V.R., Bharodia, R.K., Jethva, D.M., Rathod, R.T. and Deshmukh, S.G. (2010). Field Efficacy of Chemical Insecticides against Spotted Pod Borer, *Maruca vitrata* (Fabricius) Infesting Blackgram. *Legume Res. Intl. J*. **33**(4): 287- 290.

Srivastava, K.M. and Singh, L.N. (1976). A review of the pest complex of kharif pulses in Uttar Pradesh (U.P.) *PANS*. **22**(3): 333-335.

Summers, C.G., Haviland, D.R.C. and Godfrey, L.D. (1997). Insects and Mites. *UC IPM Pest Management Guidelines: Sugarbeet*. UC ANR Publication. 3469pp.

Swamy, S.V.S.G., Lakhsmi, R., Pathyand, and Rao, B. (2010). Biorational approaches for the management of pulse beetle,*Callosobruchus chinensis*blackgram. *J. Insect Sci*. **28**(2): 217-220.

Tahir, I.K. and Shaheen, A. (2019). Bioefficacy of *Oscheius nadarajni*against *Helicoverpa armigera* in *Vigna mungo* field. *Bodhi Intl. J. Res. in Humanities, Arts Sci.* **4**(1): 2456-5571.

Westdal, P.H. and Romanow, W. (1972). Observations on the biology of the flea beetle *Phyllotreta cruciferae* (Coleoptera,Chrysomelidae). *Uanitoba Entomol.* **6**: 35-45.

Yadav, S.K., Shweta, P., Meena, A. and Bisht, R.S. (2015). Efficacy of insecticides and bio-pesticides against sucking pests in blackgram. *Annals Plant Protect. Sci*. **23**(2): 223-226.

Yadav, S.K., Agnihotri, M. and Bisht, R.S. (2015). Efficacy of insecticides and bio-pesticides against defoliators and spotted pod borer, *Maruca vitrata* in Black gram. *Annals Plant Protect. Sci*. **23**(1): 65-68.

Yan, X., Richou, H., Moem, M., Shulong, C. and Patrick, D.C. (2012). Field evaluation of entomopathogenic nematodes for biological control of striped flea beetle, *Phyllotreta striolata* (Coleoptera: Chrysomelidae). *BioControl*. **58**: 247–256.

# 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 | Critical value |
|---|---|---|
| % sand | 26 | - |
| % silt | 45 | - |
| % clay | 29 | - |
| Textural class | Silty clay | - |
| pH | 5.6 | Acidic |
| Organic carbon (%) | 0.45 | - |
| Organic matter (%) | 0.78 | - |
| Total N (%) | 0.03 | 0.12 |
| Available P (ppm) | 20.00 | 27.12 |
| Exchangeable K (me $100^{-1}$ g soil) | 0.10 | 0.12 |
| 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 September to November, 2019**

| Month (2019) | *Air temperature (ºC) | | *Relative humidity (%) | *Total rainfall (mm) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| September | 32.4 | 26.4 | 77 | 207 |
| October | 32.7 | 24.7 | 73 | 112 |
| November | 29.7 | 19.2 | 67 | 0 |

*Monthly average,

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

**Appendix III. Analysis of variance of the data on number of aphid per plant and reduction over control (%) as influenced by different treatments**

| Sources of variation | Degree of freedom | | Mean square | |
|---|---|---|---|---|
| | Number of aphid per plant | Reduction over control (%) | Number of aphid per plant | Reduction over control (%) |
| Replication | 2 | 2 | 0.0919 | 36.81 |
| Treatment | 6 | 5 | 3.95079** | 1522.35** |
| Error | 12 | 10 | 0.04746 | 33.62 |
| Total | 20 | 17 | | |

**Significant at 1% level of probability

**Appendix IV. Analysis of variance of the data on number of whitefly per plant and reduction over control (%) as influenced by different treatments**

| Sources of variation | Degree of freedom | | Mean square | |
|---|---|---|---|---|
| | Number of whitefly per plant | Reduction over control (%) | Number of whitefly per plant | Reduction over control (%) |
| Replication | 2 | 2 | 0.21143 | 217.092 |
| Treatment | 6 | 5 | 3.61746** | 983.713** |
| Error | 12 | 10 | 0.02698 | 3.761 |
| Total | 20 | 17 | | |

**Significant at 1% level of probability

**Appendix V. Analysis of variance of the data on stemfly infested per plant and reduction over control (%) as influenced by different treatments**

| Sources of variation | Degree of freedom | | Mean square | |
|---|---|---|---|---|
| | Number of stemfly per plant | Reduction over control (%) | Number of stemfly per plant | Reduction over control (%) |
| Replication | 2 | 2 | 0.1162 | 52.421 |
| Treatment | 6 | 5 | 10.2987** | 605.963** |
| Error | 12 | 10 | 0.0873 | 15.58 |
| Total | 20 | 17 | | |

**Significant at 1% level of probability

**Appendix VI. Analysis of variance of the data on number of stink bug per plant and reduction over control (%) as influenced by different treatments**

| Sources of variation | Degree of freedom | | Mean square | |
|---|---|---|---|---|
| | Number of stinkbug per plant | Reduction over control (%) | Number of stinkbug per plant | Reduction over control (%) |
| Replication | 2 | 2 | 0.1386 | 0.299 |
| Treatment | 6 | 5 | 60.7038** | 495.438** |
| Error | 12 | 10 | 0.0852 | 3.392 |
| Total | 20 | 17 | | |

**Significant at 1% level of probability

**Appendix VII. Analysis of variance of the data on number of jassid per plant and reduction over control (%) as influenced by different treatments**

| Sources of variation | Degree of freedom | | Mean square | |
|---|---|---|---|---|
| | Number of jassid per plant | Reduction over control (%) | Number of jassid per plant | Reduction over control (%) |
| Replication | 2 | 2 | 0.09 | 101.853 |
| Treatment | 6 | 5 | 30.0727** | 561.054** |
| Error | 12 | 10 | 0.2206 | 4.665 |
| Total | 20 | 17 | | |

**Significant at 1% level of probability

**Appendix VIII. Analysis of variance of the data on flea beetle per plant and reduction over control (%) as influenced by different treatments**

| Sources of variation | Degree of freedom | | Mean square | |
|---|---|---|---|---|
| | Number of flea beetle per plant | Reduction over control (%) | Number of flea beetle per plant | Reduction over control (%) |
| Replication | 2 | 2 | 0.3276 | 7.373 |
| Treatment | 6 | 5 | 16.5563** | 518.805** |
| Error | 12 | 10 | 0.0787 | 11.016 |
| Total | 20 | 17 | | |

**Significant at 1% level of probability

**Appendix IX. Analysis of variance of the data on number of flea beetle infested leaf per plant and reduction over control (%) as influenced by different treatments**

| Sources of variation | Degree of freedom | | Mean square | |
|---|---|---|---|---|
| | Number of flea beetle infested leaf $plant^{-1}$ | Reduction over control (%) | Number of flea beetle infested leaf $plant^{-1}$ | Reduction over control (%) |
| Replication | 2 | 2 | 0.3443 | 6.931 |
| Treatment | 6 | 5 | 20.4343** | 514.452** |
| Error | 12 | 10 | 0.1076 | 8.701 |
| Total | 20 | 17 | | |

**Significant at 1% level of probability

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

| Sources of variation | Degree of freedom | Mean square | | |
|---|---|---|---|---|
| | | Number of healthy pods per plant | Number of infested pods per plant | % infestation |
| Replication | 2 | 53.1429 | 0.00619 | 7.1587 |
| Treatment | 6 | 30.7619** | 2.1154** | 60.0844** |
| Error | 12 | 1.9762 | 0.0173 | 1.5418 |
| Total | 20 | | | |

**Significant at 1% level of probability

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

| Sources of variation | Degree of freedom | Mean square | | |
|---|---|---|---|---|
| | | Number of healthy pods per plant | Number of infested pods per plant | % infestation |
| Replication | 2 | 4 | 0.34333 | 0.254 |
| Treatment | 6 | 118.746** | 7.11111** | 43.7189** |
| Error | 12 | 5.389 | 0.06778 | 0.2568 |
| Total | 20 | | | |

**Significant at 1% level of probability

**Appendix XII. Analysis of variance of the data on reduction of damage over control (%) of pod borer attacking blackgram at early pod development stage as influenced by different treatments**

| Sources of variation | Degree of freedom | Mean square | |
|---|---|---|---|
| | | Early pod development | Late pod development |
| Replication | 2 | 170.21 | 24.548 |
| Treatment | 5 | 1328.48** | 894.549** |
| Error | 10 | 25.56 | 14.876 |
| Total | 17 | | |

**Significant at 1% level of probability

**Appendix XIII. Analysis of variance of the data on plant height and number of pods/plant as influenced by different treatments**

| Sources of variation | Degree of freedom | Mean square | |
|---|---|---|---|
| | | Plant height | Number of pods plant$^{-1}$ |
| Replication | 2 | 8.19 | 1.3333 |
| Treatment | 6 | 125.984** | 52.8889** |
| Error | 12 | 2.579 | 4.2222 |
| Total | 20 | | |

**Significant at 1% level of probability

**Appendix XIV. Analysis of variance of the data on increase (%) of plant height and number of pods/plant over control as influenced by different treatments**

| Sources of variation | Degree of freedom | Mean square | |
|---|---|---|---|
| | | Increase over control (%) | |
| | | Plant height | Number of pods plant$^{-1}$ |
| Replication | 2 | 57.897 | 9.669 |
| Treatment | 5 | 178.623** | 218.063** |
| Error | 10 | 5.832 | 16.323 |
| Total | 17 | | |

**Significant at 1% level of probability

**Appendix XV. Analysis of variance of the data on pod length and its increase over control as influenced by different treatments**

| Sources of variation | Degree of freedom | | Mean square of pod length | |
|---|---|---|---|---|
| | Pod length | Increase over control (%) | Pod length | Increase over control (%) |
| Replication | 2 | 2 | 0.02144 | 86.714 |
| Treatment | 6 | 5 | 1.69184** | 743.415** |
| Error | 12 | 10 | 0.02711 | 27.96 |
| Total | 20 | 17 | | |

**Significant at 1% level of probability

**Appendix XVI. Analysis of variance of the data on number of seed pod$^{-1}$, 1000 seed weight and yield as influenced by different treatments**

| Sources of variation | Degree of freedom | Mean square | | |
|---|---|---|---|---|
| | | Number of seed pod$^{-1}$ | 1000 seed weight | Yield |
| Replication | 2 | 0.10 | 0.1651 | 0.00366 |
| Treatment | 6 | 6.31** | 59.4932** | 0.13221** |
| Error | 12 | 0.08 | 0.2278 | 0.00717 |
| Total | 20 | | | |

**Significant at 1% level of probability

**Appendix XVII. Analysis of variance of the data on increase (%) number of seed pod$^{-1}$, 1000 seed weight and yield over control as influenced by different treatments**

| Sources of variation | Degree of freedom | Mean square | | |
|---|---|---|---|---|
| | | Increase over control (%) | | |
| | | Number of seed pod$^{-1}$ | 1000 seed weight | Yield |
| Replication | 2 | 593.47 | 39.176 | 2565.15 |
| Treatment | 5 | 2951.03** | 917.665** | 280.52** |
| Error | 10 | 47.96 | 4.315 | 23.16 |
| Total | 17 | | | |

**Significant at 1% level of probability