DAMAGE SEVERITY OF MAJOR INSECT PEST OF YARD LONG BEAN AND THEIR ECO-FRIEDLY MANAGEMENT

A THESIS

BY

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CERTIFICATE

This is to certify that thesis entitled, "DAMAGE SEVERITY OF MAJOR INSECT PEST OF YARD LONG BEAN AND THEIR ECO-FRIENDLY MANAGEMENT" submitted to the faculty of Agriculture, Sher-e- Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in ENTOMOLOGY, embodies the result of a piece of bona fide research work carried out by JANNAT ARA CHOUDHURY, Registration No.: 13-05659 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 been fully acknowledged.

Dated: June, 2020
Place: Dhaka, Bangladesh

Dr. Ayesha Akter,
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Dedicated to
My Beloved Parents

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ABSTRACT

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2018 to march, 2019 to evaluate the effectiveness of some botanicals and to manage major insect pest on yard long bean. The seeds of Yard long bean variety BARI borboti-1 were used as the test crop in this experiment. The experiment comprised of the following botanicals as treatment- T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days; T_2: Neem leaf extract @ 5 ml per liter of water at 7 days interval; T_3: Datura seeds extract @ 5 ml per liter of water at 7 days interval; T_4: Black pepper seed extract @ 5ml per liter of water at an interval of 7 days; T_5: Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; T_6 : Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and T_7: Untreated control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Recorded data showed statistically significant variation for different treatments. At early pod development stage, the lowest percentage of infested pods per selected plants in number and weight basis was observed from T_6(7.63% and 3.69%)) treatment, again the highest percentage of infested pods (29.99% and 24.18%) was recorded in T_7 treatment. At mid pod development stage, the lowest infested pods per selected plants in number and weight basis was observed from T_6 (4.19% and 7.63%) treatment, whereas the highest infested pods (17.44%and 21.56%) was recorded in T_7. At late pod development stage, the lowest infested pods per selected plants in number and weight basis was observed from T_6 (5.33% and 9.40%) treatment again the highest infested pods (16.14% and 21.58%) was recorded in T_7 treatment. The highest yield was recorded from T_6 (16.57 t/ha), whereas the lowest yield from T_7 (11.60 t/ha) treatment. Botanical extracts had significant effects on yield of yard long beans. Tobacco extract treated plants produced the greatest number and biomass of yard-long beans; the treatment was followed by neem, garlic and mahogany. The latter two treatments did not show significant effect.

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LIST OF SYMBOLS AND ABBREVIATION

SYMBOLS AND ABBREVIATIONS	FULL WORD
@	At the rate of
AEZ	Agro-ecological Zones
Agric.	Agriculture
Agril.	Agricultural
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
^{o}C	Degree centigrade
Cm	Centimeter
CV%	Percentage of Co-efficient of Varience
et al.	And others
etc.	Etcetera
g	Gram
i.e.	That is
J.	Journal
kg	Kilogram
LSD	Least Significant Difference
mg	Milligram
MOP	Murate of Potash
No.	Number
RCBD	Randomized Completely Block Design
Res.	Research
SAU	Sher-e-Bangla Agricultural University
t	Ton
TSP	Triple Super Phosphate
UNDP	United Nations Development Programme
Viz.	Namely
%	Percent

CHAPTER I

INTRODUCTION

Yardlong bean, *Vigna unguliculata* (L.) Ssp. Sesquipedalis is a very common and important vegetable crop which is cultivated year around in Bangladesh. It is belong to the leguminosae family which is cultivated mainly for its crisp and tender green pod. It can be consumed both fresh as well as in cooked form. It is also called as asparagus bean, Chinese long bean, string bean, snake bean, snake pea, bodi and borboti (Purseglove, 1977).

It is an inexpensive source of vegetable protein, vitamin A, thiamin, riboflavin, calcium, vitamin C, phosphorus, sodium, potassium, magnesium and cobalt. It is a highly nutritive vegetable containing a good amount of digestible protein both in pods (23.5-26.3%) and in leaves (Ano and Ubochi, 2008). A serving of 100g of yard long bean contains 50 calories, 9.0g of total carbohydrates, and 3.0g of proteins, 0.2g total fat and 0.8g of minerals (Anonymous, 2013). Yard long bean is one of the economically important vegetable crops in Bangladesh. The area occupied by this crop was 5896.34 hectare and the production was 21674 tons during the year 2013-2014 (Anon., 2014).

The area occupied by this crop was 5857.49 ha and the production was 21348 t during the year 2008- 2009 (Anon., 2010). It is cultivated in Chittagong, Chittagong Hill Tracts (CHTs), Faridpur, Noakhali, Camilla and Rangpur districts in Bangladesh (Uddin, 2013). But the production of yard long bean is increasing in Dhaka, Chittagong, Camilla, Narsingdi, and Jessore districts and also other districts in Bangladesh day by day due to its increasing requirement.

The cultivation of yard long bean faces various problems including pest management (Rashid, 1993). It is attacked by a number of insects like aphid, pod borer, thrips, red mite, leaf miner, leaf beetle, green sting-bug, jute hairy caterpillar, hooded hopper and semi-looper in descending order in Bangladesh (Uddin *et al.,* 2013). It was revealed that aphid and pod borer were the major insect pests. The production of yard-long bean is affected due to the frequent occurrence of these insect (Begum *et al*., 1991; Pedigo, 2002). *Aphis spp*.and pod borerattack yard-long beans from seedling to pod-maturing stages of plants, cause significant and economic damages to different crops

including beans (Attle *et al*., 1987). But the production of Yard-long bean is affected due to the frequent occurrence of aphid, *Aphis sp.*(Homoptera:Aphididae), a ubiquitous group of arthropods (Pedigo, 2002).The insect attack plant stems, buds, leaves, flowers and pods of the plants (Shrivastava and Singh,1986).Both nymphs and adults of aphid suck cell sap of infested plants while feeding they inject a toxin along with the salivary secretion into host plants. Aphids also secrete honeydew, which, by enhancing the growth of sooty moulds, interferes with the photosynthetic ability of plants (Rizkalla *et al*., 1994). The pest causes up to 40% reduction of crop yields in Asia according to Attle *et al.* (1987) reported as high as 100% yield reduction of different bean crops due to aphid infestation. Beside other damages like pod-borer also cause significant damage by boring on the pod and reducing the yield value (Alam *et al.,* 2005). Jassids are the sucking pest.Nymphs and adults damage their hosts by sucking at plant tissues. While sucking, the insects inject toxic compounds which may lead to block plant vessels**.** Epilachna beetle feeds exclusively on the plants. Both the grub and adult feed on the epidermal tissues of leaves by scraping surface and damage up to 80% of plants (Rajagopal and Trivedi, 1989).The grubs confine their attack to the lower surface of the leaves and adults usually feed on the upper surface of the leaves (Pradhan *et al.,* 1990)**.**

In order to protect the crops from the damage of insect, Bangladesh often apply synthetic chemical insecticides. Although synthetic insecticides usually provide quick and adequate control for the time being, they are usually expensive and leave long-lasting residues over the exposed surface of the crops, in soil and water (Hussain, 1989). In fact, the use of chemical pesticides has quickly become widespread worldwide and it is estimated that 35 billion kg of pesticides are applied annually (FAOSTAT, 2014). However, it is also estimated that pests still cause the loss of 37% of 50 potential crop yield (Pimentel, 2005). Pesticides can also have many negative side effects including: human health impacts, water contamination, killing of non-target species, residues in food, and the onset of pesticide resistance (Carvalho, 2006; Chagnon *et al*., 2015) there is renewed interest in the application of botanical pesticides for crop protection (Debach and Rosen, 1991; Pedigo, 2002).

Plants are rich sources of natural substances that can be utilized in the development of environmentally safe methods for insect control. (Sadek, 2003). The use of plant extracts (botanical insecticides) to protect crops and stored products is as old as crop

production. Indeed, before the development and commercial success of synthetic pesticides beginning in the 1940s, botanical insecticides were significant weapons in the farmer's arsenal against crop pests (Isman, 2008). For example, azadirachtin acts on the hormonal system; insects don't develop resistance in future generations, thereby making it a sustainable solution. There have been a large number of plant products, which possess pesticides and have been used successfully for controlling various pest in field and laboratory conditions. (Bajpai and sehgal, 2002). Botanical insecticides tend to have broad-spectrum activity, are relatively specific in their mode of action, and easy to process and use. They also tend to be safe for higher animals and the environment (Anonymous, 1991). Botanical products like tobacco leaf extracts, neem oil and other extracts which can be easily and cheaply collected in rural Bangladesh, have been found promising and useful for the control of insect pests. Bangladesh is rich in biodiversity. This research in botanical pesticides has a great scope to find out the botanical pesticides which are eco-friendly plant based for sustainable management of yard long bean in the field.

Keeping the above in mind, the present study was under taken to fulfill the following objective:

- To identify the incident of insect attack in different stages of Yard long bean growth
- To identify the damage severity caused by insect pest in different growing stage followed by yield and
- To find out the efficiency of different botanicals against the major insect pest of yard long bean.

CHAPTER II

REVIEW OF LITERATURE

Yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Walp) is one of the popular vegetable crops and it is a vigorous climbing vine. Yard long bean is an important leguminous vegetable grown very profitably all over Bangladesh. It is one of the vegetables having exporting potential in Bangladesh. It is a highly nutritive vegetable containing a good amount of digestible protein. The cultivation of this crop faces various problems including the pest management (Rashid, 1993). Yard long bean is especially attractive to aphids (*Aphis fabae*), pod borer (*Maruca vitrata*), Jassid (Amrasca biguttula) and Epilachna beetle (*Epilachna varivestis*). The insect pests have been reported as one of the serious problems to yard long bean cultivation in the country. Aphid and jassid the most destructive pest, causes damage by sucking sap from flowers, buds, pods and tender branches of the plants and reduces the viability of plant. The use of plant extracts to control pests is not a new innovation, as it has been widely used by small-scale subsistence farmers. The use of locally available plants in the control of pests is an ancient technology in many parts of the world. Therefore, some of the effective and educative research findings in this aspects on yard long bean so far been done at home and abroad have been reviewed in this chapter under the following headings and sub-headings:

2.1 Major insect pest of yard long bean:

2.1.1 Aphid

Aphids are small sap-sucking insects. Common names include greenfly and blackfly maturing rapidly, females breed profusely so that the number of these insects multiplies quickly. Winged females may develop later in the season, allowing the insects to colonize new plants (Russell, 1968).

2.1.1.2 Systematic Position

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hemiptera

Suborder: Sternorrhyncha

Family: Aphididae

Genus: Aphis

Species: *A. craccivora*

2.1.1.2Origin and distribution

Aphids are small bugs which feed on plants. They are distributed worldwide, but are most common in temperate zones. Aphid species diversity is much lower in the tropics than in the temperate zones (Berry and Taylor, 1968). They can migrate great distance mainly through passive dispersal by winds. Winged aphids may also rise up in the day as high as 600m there they are transported by strong winds (Scott *et al*., 1990).

2.1.1.3Nature of damage

The aphid feeds by sucking fluid from the stem terminal shoots, petioles, flowers and pods (Asiwe *et al.,* 2005). Among the insect pests, aphid, *Lipaphis erysimi* (Kalt.) is a serious insect pest, infesting the crop right from seedling stage to maturity but that ravages the crop during the reproductive phase and act as a limiting factor in the production (Bashir *et al.,* 2002 and Laamari *et al.,* 2008). The infestation of pest not only results in reduced yield of the seeds but also reduces the oil content upto 66.87 % (Singhvi *et al*., 1973). Besides these, aphids secrete honeydew, which encourage the growth of the sooty moulds giving the stem and leaves black appearance and interfere the photosynthesis.

2.1.2Jassid

Amrasca biguttula, is a subspecies of leafhopper.*A. biguttulabiguttula* causes damage right from seedlings to the fruit setting stage, resulting in a loss of 50-63.41 % in yield (Bindra and Mahal, 1981; Sharma and Sharma, 2001).

2.1.2.1 Systematic position

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Hexapoda
Class: Insecta
Order: Hemiptera
Suborder: Auchenorrhyncha
Infraorder: Cicadomorpha
Super-family: Membracoidea
Family: Cicadellidae
Sub-family: Typhlocybinae
Tribe: Empoascini
Genus: *Amrasca*
Species: *A. biguttula*
Subspecies:*A. biguttula biguttula*

2.1.2.2Origin and Distribution

*Amrasca biguttula*is an insect of southern Asia. On leaf surfaces, the insect tends to move about diagonally, when distributed it immediately jumps and fly away(Jayasimha *et al*., 2012).

2.1.2.3Nature of damage

Jassids are the sucking pest the females lay their eggs within the leaf vein tissue, mostly on the downside of leaves. Nymphs and adults damage their hosts by sucking at plant tissues. While sucking, the insects inject toxic compounds which may lead to blacked plant vessels**.** Jassid (*Amrasca biguttula*), Sucking insects pests are one of the serious pest of legume. Mukhtar (2009) considered jassid as one of the major insect pests, which sucked the sap from the leaves of plants. Besides, that they also inject toxic material into the tissue of the plant (Sattar *et al.*, 1984). The insect secrete

honeydew, and sooty mold often grows on this, restricting the amount of light reaching the plant's photosynthetic surfaces this symptom gradually affecting plant growth and cause reduction in fruit numbers and yield (Jayasimha *et al*., 2012; Jayarao, *et al*., 2015).

2.1.3Pod borer

Maruca vitrata is a pantropical insect pest of leguminous crops. Its common name includes the maruca pod borer, bean pod borer, or legume pod borer. Its feeding sites on plants are flower buds, flowers and young pods

2.1.3.1Systematic position

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Crambidae

Genus: *Maruca*

Species: *M. vitrata*

2.1.3.2Origin and distribution:

The legume pod borer (LPB), *Maruca vitrata* Fabricius (Lepidoptera: Pyraloidea: Crambidae; Syn: *Maruca testulalis*), is distributed through the tropical and subtropical regions of the world (Katayama and Suzuki, 1984). Although the Indo-Malaysian region is considered to be the most probable region of origin for the genus Maruca, including M. vitrata (Taylor, 1967) the geographic range of this insect extends from northern Australia and East Asia through sub-Saharan Africa (Kee and Fang, 1985).

2.1.3.3Nature of damage:

Host plants are mainly species from the Family Fabaceae (leguminous plants) (Sharma, 1998 and Arodokoun *et al*., 2006). The cultivation of these legumes for food has increased due to the advent of double cropping and inter-cropping systems in

subtropical regions (Sexena, 2000) and has resulted in M. vitrata emerging as major threat to legume production in developing and underdeveloped nations.Pod borer, *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae) is a major pest of country bean in Bangladesh. Besides pod-borer also cause significant damage by boring on the pod and reducing the yield value. Its larvae damage stems, peduncles, flowers and pods of the crop (Alam *et al*., 2005).

2.1.4Epilachna beetle

The Mexican bean beetle, *Epilachna varivestis*, is a species of lady beetle that can be an agricultural pest. It is one of the new North American lady beetles that feed on plants rather than other insects(Pradhan *et al*., 1990)**.**

2.1.4.1 Systematic position

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Coccinellidae

Sub-family: Epilachninae

Genus: Epilachna

Species:*E. dodecastigma*

2.1.4.2Origin and Distribution:

Epilachna beetle is the most destructive specially in South Asia. It is widely distributed in Asia, Europe, Australia, America, and West Indies (Rajagopal and Trivedi, 1989).

2.1.4.3Nature of Damage:

This beetle feeds exclusively on the plants. Both the grub and adult feed on the epidermal tissues of leaves by scraping surface and damage up to 80% of plants (Rajagopal and Trivedi, 1989). Thirty-five to seventy-five percent leaves were severely damaged by grubs and adults (Srivastava and Singh, 1986). The grubs confine their attack to the lower surface of the leaves and adults usually feed on the

upper surface of the leaves (Pradhan *et al.*, 1990)**.** Epilachna beetles are serious pests of vegetables in Bangladesh (Khan *et al*., 2000). Epilachna beetles are locally known as hadda beetles and common throughout the country and cause a considerable damage to a number of solanaceous, cucurbitaceous and leguminous crops (Anam *et al*., 2006; Rahaman *et al*., 2008; Islam, *et al.*, 2011). The presence of this pest is one of the limiting factors in the vegetable production causing qualitative as well as quantitative losses.

2.2 Use of botanicals against the major insect pest of yard long bean

2.2.1Use of Botanicals against aphid

Dutta *et al*. (2016) carried out an experiment to evaluate the efficacy of four new generation insecticides along with a botanical against aphid and their toxicity to coccinellid beetles and foraging honeybees Among the treatments, Azadiractin 1EC appeared to be safest to coccinellid beetles and foraging honeybees because it recorded the highest number of beetle (7.50 /5 plants) and honeybee (9.64 /plot/5 min) population at 7 DAS.

Shiberu and Negeri (2016) conducted an experiment to evaluate three locally available botanicals. These materials were evaluated for their efficacy against aphids. Extracts of neem (*Azadirachta indica*) seed, Hop bush (*Dodonae angustifolia*) fresh leaf and Lemon grass (*Cymbopogon citrates*) gave performance which was positive. Powdered neem seed, *Dodonae angustifolia* fresh leaf and leaves of *Cymbopogon citrates* caused moderately mortality percent against aphid within 3 days after applications. Higher damage and low yield were found in control. This study indicated that botanicals could be recommended as an alternative management option of *Brevicoryne brassicae* (L.).

The aphid is an insect pest of economic importance in the production of pulses in Ethiopia. The economic yield losses in Field pea due to *A. pisum* was calculated to be up to 230 kg/ha. Control methods include the application of insecticide and early planting. Reliance on synthetic chemicals to control pests has resulted in destruction of non-target organisms (parasitoids and predators) thereby affecting biological diversity. Garlic bulbs *(Allium sativum*), Endod (*Phytolacca dodecandra*) and Neem seeds (*Azadirachta indica*) grounded and prepared at 5 and 10% dilutions was tested

for their effect on aphid. Both levels of Garlic and 5% Neem have induced mortality within 24 hours of treatment application. (Megersa, 2016)

According to Kora and Teshome, (2016) green pea aphids (*Acrythosiphon pisum*) are among the most important pests challenging field pea production. Although there are some insecticides, cost and environmental hazard necessitates the development of safe and effective management options. With this intent Aqua's extract of Chilly, Garlic, Ginger and Mexican marigold were evaluated for their insecticidal property. ANOVA for after spray aphid count depicted that there was significant difference ($P<0.005$) between treatments. The maximum number of aphids/plant (7) was recorded from untreated check while the minimum (0) was from Chilly, Ginger and Mexican marigold treated plots. Similarly, grain yield ANOVA has revealed significant differences ($P<0.05$) between treatments; the highest grain yield (2511.3kg/ha) and the lowest (1846kg/ha) was obtained from Mexican marigold and chili treated plots, respectively. This result depicted that Mexican marigold was the most effective botanical insecticide against pea aphids. Therefore, foliar sprays of Mexican marigold is recommended at a rate of 4 kg/ha.

Sarwar (2013) pointed that resistance in aphid to pesticides appears to have been the cause of failure in controlling this pest in certain cropping systems. This study is to report the insecticidal property of botanicals and their potential as organic pest control agents for field management of aphid. The effectiveness of four botanical pest control agents such as, Tobacco *Nicotiana tabacum* L., Garlic *Allium sativum* L., Goosefoot *Chenopodium album* L., and *Aloe vera* L., was assessed through foliar applications on canola (*B. napus*) crop. The toxicity of botanicals differed significantly depending upon the treatment applied. The *A. vera* (Aloeaceae) and to a greater extent *N. tabacum* at 10% concentration were the most effective botanicals and rated parallel for effectiveness in treated crop and had the least aphid's damage and enhanced yield across all the season followed by *C. album* and *A. sativum* relative to the untreated control that had the most damaged plants by pest resulting in reduced yield. Consequently, the performances of *A. Vera* and *N. tabacum* as botanical pesticides were observed the best in reducing pest and seed damage, as these did not induce any adverse effect on plant and showed that there is a prospective to use them in an integrated pest management system, being safe and economical production and protection.

Iqbal *etal.* (2011). find out the effect of six different botanical extracts- Orange peel *(Citrus sinensis*); Bitter goard (*Momordica dioica*); Garlic (*Allium vineale*); Mari gold; Hot pepper (*Capsicum frutescens*) and Tobacco (*Nicotiana tabacum*) extract on aphid. Aphids were deliberately exposed to the above botanical extracts and then the number of live and dead aphids was counted in meter square ring on tagged spikelet's. The botanical extracts showed varying effect on aphid population. Application of Orange Peel extract inflicted consistently the maximum level of aphid mortality (65.69%) followed by Garlic (57.91%), Tobacco (57.90%).

2.2.2 Use of Botanicals against Jassid:

Dehariya *et al*., (2018) pointed that performance of some botanical products against the sucking pest. The treatment included Triazophos 40E.C. 0.04%, Neem oil 1 %, Achook 5 s%, NSKE 5%, Karanj oil 1%, Eucalyptus oil 1% and an untreated control. Observation on population of sucking pests (aphids and jessed) was recorded before treatment and 3, 7 and 10 days after each spraying. The results revealed that Triazophos 40E.C. 0.04% was significantly superior over all the botanical treatments did not significantly shoot damage in different treatments ranged between 3.9 to 10.1%. Highest healthy fruits yield (24.76q/ha) was recorded in the treatment of Triazophos 40E.C. 0.04% followed by the treatment of neem oil 1% (20.54 q/ha healthy fruits), and both the treatments were statistically at par Yields in remaining treatments were at par and ranged between 19.57 and 15.23 q/ha. Lowest yield (10.50 q/ha healthy fruits) was registered in untreated control. Highest cost benefit ratio of 1:6. 31 were in treatment of Triazophos 40 EC 0.04%. Application of neem oil 1% registered the cost benefit ratio of 1:1.79 and found was most economical.

Rajput *et al.,* (2017) found that botanical extracts are better for use in organic food production in the world, and also can take part in a better role in the production and post-harvest protection of food. Bio-extracts can provide a greater role in future for control pests and reduce the usage of highly toxic pesticides. The research was conducted to determine the efficacy of botanical extract against jassid, *Amrasca biguttula* (Ishida) using of bio-pesticide, neem (*Azadirachta indica*), Datura (*Datura stramonium*) and eucalyptus (*Eucalyptus terticornis*) while their efficacy was compared with an untreated control plot. Results indicated that overall maximum mean population was recorded in Datura followed by eucalyptus and neem. The

highest mean reduction percent was recorded in Datura as compared to neem and eucalyptus, whereas the maximum yield obtained were seen by Datura followed by neem and eucalyptus. According to statistically a significantly results were observed between all treatments as compared to control groups.

Siddiqua *et al.,* (2016) evaluated the efficacy of nine botanicals against jassid. The nine botanical treatments were neem leaf extract @ 100 ml L-1 of water, turmeric powder @ 20 g L-1 of water, coriander powder @ 20 g L-1 of water, black pepper powder @ 20 g L-1 of water, chili powder @ 20 g L-1 of water, Garlic extract @ 100 g of grated and crushed garlic cloves per L of water, eucalyptus oil @ 5 ml L-1 of water, mahogany oil @ 5 ml L-1 of water, neem oil @ 5mlL-1 of water. Among the tested botanicals neem leaf extract with 100 ml L-1 water and chili powder 20 g L-1 water after 24, 48 and 72 hours of application exerted the lowest jassid population. The botanical treatments have insignificant effect on the population of beneficial. The neem leaf extract with 100 ml L-1 water and neem oil with 5 ml L-1 water had greater effect on cotton jassid and revealed significantly lower levels of leaf infestation by number. Plots treated with neem leaf extract with 100 ml L-1 water and chili powder with 20 gL water resulted in significantly higher yield than that of the control.

Alam *et al.,* (2010) state that Experiments were carried out to investigate the population abundance and to determine the efficacy of three botanical oils (Neem, Mahogany, Karanja) against Jassid, *Amrasca devastans.* The Jassid population varied significantly with the application of insecticide and botanicals. Admire 200 SL give the best result among the treatment. Out of three botanicals Karanja repelled 93.33%, where as Mahogany and Neem repelled 86.66 and 63.33%.The effectivity of botanicals and synthetic insecticides was found in the following order: Karajan oil >Mahogany oil >Neem oil.

The effectiveness of three botanical oils (Neem, Mahogany and Karanja) were evaluated in this study for controlling okra jassid. Findings of this study revealed that jassid population was significantly different with the application of different control measures. Percent area of burnt leaf, number of burnt leaf plant-1, number of fruit plant-1 and plant height were significantly different with the application of different

control measures. Botanical oils were effective to some extent but among the botanical oils neem oil was found most effective against jassid (Islam, 2009).

2.2.3Use of Botanicals against pod borer:

Giri Babu *et al*., (2018) investigate on field efficacy of some botanicals viz., Aloevera (*Aloe vera*), Nirgundi (*Vitex negundo*), Datura (*Datura stramonium*), Calotropis (*Calotropis gigantean*), Soapnut (*Sapindus mukoros*), Arusa (*Adathoda vasiva*) @ 5% aqueous extract and Pongamia soap (*Pongamia pinnata*) @ 1% against pod borer, *Helicoverpa armigera* Result revealed that Nirgundi @ 5% (w/v) was most effective (3.06 larvae / 5 plants) and significantly superior to all other treatments followed by Calotropis @ 5% (w/v), Pongamia soap @ 1% (w/v), Arusa @ 5% (w/v) and Datura @ 5% (w/v), and population ranged between 3.47 to 3.78 larvae / 5 plants, and were at par with each other. The least effective treatment was Ghikavera @ 5% (w/v) (3.98 larvae / 5 plants), but significantly better than control (4.71 larvae/ 5 plants). Overall result revealed that nirgundi leaf extract has good potential to control *H. armigera.*

According to Selvam, (2018) Efficacy of botanicals and entomogenous fungi was determined against pod borer complex of spotted pod borer, *Maruca vitrata* and gram blue butterfly, and *Euchrysops cnejus*. Azadirachtin (0.03%) formulation was effective against *M. vitrata* where 50.63% and 65.8% reduction of flower and pod damage, respectively, was recorded over untreated control. Neem oil 2% treatment was also significantly similar in activity with a reduction of flower and pod damage by 57.8% and 62.22%, respectively, caused by *E. cnejus*. Based on various parameters recorded, *Metarhizium anisopliae* and *Beauveria bassiana* were less active compared to botanicals. The impact on natural enemies was also determined, and it was observed that *Adhatoda* leaf extract up to 10% was safest and a maximum population of coccinellids (2.14 beetles/plant) and spiders (0.97 spiders/plant) were recorded. In terms of crop yield, the highest yield of 750 kg/ha was achieved after the treatment of neem formulation having 0.03% of azadirachtin over the untreated crop (433 kg/ha).

Ahmed *et al.,* (2015) evaluated that efficacy of the aqueous extracts of black pepper, chili, turmeric, coriander, neem, basil and garlic plants, and oils of neem, eucalyptus and mahogany seeds against the infestation of pod borer, *Maruca vitrata*. The plant extracts and oil treatments were used with doses of 20 g/l and 5ml /l water, respectively. In control treatment tap water was sprayed. The application of the

treatments was started from the advent of infestation and repeated 6 times at 7 day interval. The mahogany and neem oils, and chili extract provided statistically lower level of pod infestation of country bean compared to other treatments. All the plant materials exerted statistically higher and significant infestation reduction over control, and did not affect flower production of the crop. Overall findings indicated that the neem oil, mahogany oil and black pepper powder may be considered as an effective option for the management of pod borer.

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Jagdish *et al*., (2014) conducted a field experiment to evaluate the relative efficacy of eight biopesticides against gram pod borer legume pod borer. The population was recorded at different days after spraying ofbio-pesticides. Significant effect of bio-pesticides on percent webbing by *M. vitrata*, at First spray application showed minimum (32.00/25shoots) in NSKE 5.0 % @ 50 g/lit. The pod borer *M. vitrata* was found lowest in Spinosad 45%ww @73g.ai/ha (4.50%), followed by NSKE 5% (4.81%) and *B. bassiana* DOR SC @ 1.89gm/lit (5.39%) as compared to control (14.49%). Grain yield varied from maximum of 1200 kg/ha in Spinosad 45%ww @ 73g.ai/ha followed by 1191.67 kg/ha as compared to 708.33kg/ha in untreated control condition.

Chandra Shekhara *et al*., (2014) revealed that different biorationals for eco-friendly management of gram pod borer, *Helicoverpa armigera* (Hubner). Among different biorationals used, azadirachtin 3% WSP @ 400 g/ha sprayed plot recorded minimum

larval population of 0.33, 0.50 and 0.00 per ten plants at seven days after first, second and third sprays, respectively with lowest of 9.55 per cent pod damage and highest grain yield of 1596 kg/ha followed by azadirachtin 6% WSP @ 200 g/ha which received larval population of 0.05 0.64, 1.00 and 0.58 per ten plants at seven days after first, second and third sprays, respectively with grain yield of 1515.36 kg/ha and were on par with each other. Agniasthras 5% proved to be the next best treatment.

Rahman *et al.,* (2014) reported from an experiment four botanicals viz., mahogany oil, mahogany seed extract, tobacco leaf extract, neem seed kernel extract along with one synthetic chemical, cypermethrin were tested for their efficacies against *H. armigera.* The lowest fruit infestation, both by number and weight, was observed in neem seed kernel extract (27.15%, 22.29%) treated plot which was statistically similar to tobacco leaf extract (27.71%, 23.31%) treated plot and cypermethrin (28.87%, 25.44%) treated fruits. While no significant difference was found among mahogany oil, mahogany seed extract and control treatments. Percent infestation reduction over control was the highest in neem seed kernel extract (30.08%) followed by tobacco leaf extract (28.68%). The highest yield (18.14 t/ha) and the highest MBCR (2.99) were also gained from neem seed kernel extract treated fruits.

Byrappa *et al.*,(2012) recorded that biopesticides were NSKE (5%), HaNPV (250 LE/ha), BT (1kg/ha), neem oil (2%), Panchagavya (3%), Clerodendron + Cow urine extract (10%) and sequential spray of HaNPVBt -NSKE, Bt-NSKE-HaNPV and NSKE-HaNPVBt. FYM (9.5 t/ha) and bio digester liquid (6,500 L/ha) which were applied to organic plots. Among biopesticides, sequential application of NSKE-HaNPV-Bt was effective against insect pests. HaNPV was effective against *H. armigera* larvae, but ineffective to other pod borers. Panchagavya and clerodendron + cow urine extract were ineffective in reducing the pod borer incidence. Among biopesticides treated plots, sequential application of NSKE-HaNPV-Bt recorded higher grain yield (10.01q/ha) whereas, package of practices followed treatment (inorganic plot) recorded 11.37 q/ha grain.

2.2.4Use of Botanicals against Epilachna beetle:

Ara *et al.,* (2015) carried out an experiment on the larvicidal efficacies of some indigenous plant seed extracts against epilachna beetle extracts of ata (*Annona squamosa*), neem (*Azadirachta indica*), dhutura (*Datura metel*) and castor (*Ricinus*

communis) seeds were evaluated for their larvicidal properties against the larval stage of *E. vigintioctopunctata*. The result revealed that all the tested plant extracts had more or less insecticidal effect against the larvae and their progeny. Among the plant extracts, ata seed extract in methanol solvent performed the highest toxicity (LD_{50} value 0.031 mg/insect) in larval stage after 72 hours exposure time. The effects of the extracts on fecundity, fertility and F1 adult emergence of the epilachna beetle at doses 4.0, 2.0 and 1.0 ml/l of water including untreated control were also evaluated. The result indicated that, among the extracts, ata seed extract at maximum dose (4.0 ml/l water) showed the highest efficacy with the inhibition of total eggs (74.1%), viable eggs (80.4%) and number of emergent adult progeny (87.3%). The result also revealed that the number of eggs, number of viable eggs and F1 progeny production decreased with the increase of doses. All the treated doses effectively reduced the epilachna beetle as compared to untreated control.

Podder *et al.,* (2013). reported that Neem Oil, Mahogany Oil, Bishkatali Leaf Extract, pithraj seed extract and Diazinon 60 EC were assessed for their effectiveness in managing Epilachna beetle, *Epilachna dodecastigma* (Wied.). The highest incidence of Epilachna beetle/Plant was 7.67 and the highest percentage of infested leaves (11.27%) was observed at 60 DAT. Beetle Population along with percentage of infested leaves declined at fruiting stage due to the maturity of the leaves. The effectiveness of the treatments against the pest was evaluated on the basis of percent reduction of beetle population at 24, 48 & 72 HAT in field level. In all spray intervals, mean reduction percentage showed a declining trend in Bishkatali Leaf Extract @ 8% other than 2nd spray. Though Neem, mahogany, biskatali, pithraj treated plots showed significant variation over untreated control in aspects of percent population reduction of Epilachna beetle, neem oil at 13% concentration was the most effective among them.

Islam *et al.,* (2011) reveiled that *Epilachna vigintioctopunctata* is an important pest that causes considerable economic losses to many crops. The crude aqueous extracts of leaves from three indigenous plants namely *Ricinus communis, Calotropis procera* and *Datura metel* were used against this beetle. Larvicidal bioassays of the extracts showed the following order of toxicity: *R. communis* (LC_{50}=18.40%) >*C. procera* (LC_{50}=23.70%) >*D. metel* (LC_{50}=29.61%). Subsequent data on some vital life-history traits were promising because the extracts significantly reduced both oviposition and

egg-hatch, prolonged larval duration (P<0.001), and inhibited pupae formation and adult emergence (P<0.05). However, female ratio was not significantly affected by the treatments. Relevance of these findings on the control of this phytophagous species has been discussed.

Rahman*et al.,* (2008) conducted an experiment to find out the possibility of the management of epilachna beetle using botanical and synthetic pesticides. A total of three approaches viz., Tephrosia leaf extract (20g fresh leaves/100ml water), Diazinon 60 EC @ 2 ml/L of water and an untreated control were evaluated. The Tephrosia leaf extract performed well for effective control of epilachna beetle with its different stages and also performed highest yield followed by a synthetic pesticide (Diazinon 60 EC). On the other hand the highest plant infestation was observed in untreated control and also performed lowest yield. The Tephrosia leaf extract is inhibiting or killing the beetle and treated as a environment friendly pest control method.

2.3Effectiveness of botanicals to control pests:

Mishra (2018) found that grain legumes remain important to meet the projected targets relating to food and nutritional security worldwide. The complementation of cereal-based food with grain legumes is a vegetarian diet with high-quality protein. However, the performance of these crops is severely influenced by a number of biotic and abiotic stresses, of which pests and pathogens remain the crucial affecting plants at different growth stages. Chemical pesticides are mainly employed across the world for management of pests and pathogens. The risk associated with the environmental pollution and health hazards to man, plants, domestic animals, and wild life makes these pesticides ecologically unacceptable. Also, major damage caused by pests of grain legumes are systemic in nature, and their management through chemicals often yields unsatisfactory outcome. This has led to increasing shift in the attention of scientific community towards eco-friendly and safer technologies for pest management in legumes. Sustainable protection demands implementation of strategies that rely upon biological control agents (BCAs) and their formulations. In recent years, such formulations have been promoted to mitigate the pest problem and improving crop yield. This review presents an updated summary on BCAs including the present status of BCA application, mode of actions, and delivery systems under controlled and field conditions to address major pest problems on legume crops.

Azad and Sarker (2017)carried out an experiment to evaluate the efficacy of nine botanical extracts on plant growth, yield and pest management. Aqueous extracts of dried leaves of *Nicotiana tabacum, Aegle marmelos, Ficus hispida, Lawsonia inermis, Vitex negundo* and seeds of *Carum roxburghianum, Corchorus capsularis* and *Swietenia macrophylla* and bulb of *Allium sativum* were prepared and sprayed. Out of these nine botanicals, *Nicotiana tabacum* extract showed best performance against pest attack in field. The leaf extract of *Ficus hispida* also showed good efficacy in the protection of plant from pest attack. The highest plant length and fruit yield were recorded in the treatment of *Nicotiana tabacum*, whereas second and third highest productions were observed in *Aegle marmelos* and *Ficus hispida* treatments, respectively. Both *Allium sativum* and *Carum roxburghianum* extracts were found to show phyto-toxicity to eggplant and hampered the plant growth and yield.

Chaubey, (2017) pointed that continuous use of synthetic pesticides has increased the risk of ozone depletion, neurotoxicity, carcinogenicity, teratogenicity and mutagenic effects among non-target species and cross-resistance and multi-resistance in insects. These have created increased public awareness on human safety and possible environmental damage diverting attention towards other alternatives especially the use of plant products in stored-grain insect pest management. In the present study, essential oils of Allium sativum (*A. sativum*) and Aegle marmelos (*A. marmelos*) have been evaluated for their repellent, insecticidal, anti-ovipositional and acetylcholine esterase inhibitory activities against maize weevil, *Sitophilus zeamais* (*S. zeamais*). Garlic, Allium sativum and bel, Aegle marmelos essential oils have been isolated and evaluated for repellent, insecticidal, oviposition inhibitory and acetyl cholinesterase enzyme inhibitory activities in maize weevil, *Sitophilus zeamais*. One-way analysis of variance (ANOVA, $p<0.01$), correlation and linear regression analysis were used for data analysis. In repellency assay, both essential oils showed repellent activity against *S. zeamais* adults. These essential oils caused toxicity in *S. zeamais* adults when applied by fumigation and contact methods. In fumigation toxicity assay, median lethal concentrations (LC_{50}) recorded were 0.297 and 0.22 μL cm–3 air, 0.312 and 0.184 μL cm–3 air of *A. sativum* and *A. marmelos* oils after 24 and 48 h exposure of S. zeamais adults, respectively. In contact toxicity assay, median lethal concentrations (LC_{50}) were found 0.208 and 0.116 μL cm–2 area and 0.227, 0.146 6,37 μL cm–2 area of *A. sativum* and *A. marmelos* oils after 24 and 48 h exposure of *S. zeamais* adults,

respectively. Essential oils of *A. sativum* and *A. marmelos* oils were found to inhibit progeny production by inhibiting oviposition in *S. zeamais* adults when exposed to sub-lethal concentrations. Fumigation of *S. zeamais* with *A. sativum* and *A. marmelos* oils caused neurotoxicity by inhibiting acetylcholine esterase enzyme (AchE) activity*A. sativum* and *A. marmelos* oils can be used as alternative in management of stored-grain insects.

According to Karani *et al*., (2017) botanical Pesticides (BPs) have been used as alternative to synthetic pesticides in agricultural systems worldwide. The BPs are believed to be safe to the environment and are used in pest control to avoid pesticidal pollution, which is a universal problem. In this review, authors provide comprehensive information on the use of BPs in management of common bean pests in Africa. This piece of literature is useful due to major negative side effects to the environment as well as human health arising from synthetic chemicals. It is due to this reason that the authors composed this review to provide insights on potentiality of the BPs. Generally, it is believed that majority of Africans, feel that BPs are their heritage, thus any technology derived from the BPs is likely to be highly adopted. This review highlights importance, preparation and different methods of applying the BPs so that farmers and other users of this document can easily understand quick methods of using BPs as alternative to synthetic pesticides in combating pest. Furthermore, areas for future research have been highlighted to establish the need of moving the BPs industry forward for pest management in common bean and other crops.

Synthetic insecticides have been used to suppress the growing population of jassid, but the use of pesticides on a large scale for majority of insect pest can lead environmental pollution that becomes a challenge for human health and other associated animals. Meanwhile, insect pests have developed resistance against these pesticides. Consequently, the entomologists diverted from synthetic pesticides to biopesticides (particularly plant extracts) are being used from past few years against different insect pests. Different plant extracts such as neem, heenge, eucalyptus, akk, datura etc. has been used on a large scale against many insect pests and their uses have been proved un-hazardous and ecofriendly (Khaskheli, 2007).

Oparaeke *et al.*,(2004) demonstrated that efficacy of aqueous neem and *Eucalyptus* leaf extracts in mixtures containing extracts of other plant species was investigated for the management of the legume flower bud thrips, a major post-flowering insect pest of cowpea in the Research Farm of the Institute for Agricultural Research, Ahmadu BelloUniversity, Zaria, Nigeria. The extracts mixtures were applied at 10:10% w/v in equal ratio and sprayed four times at weekly intervals. The results showed that thrips pressure on cowpea flowers was significantly ($P < 0.05$) less (< 1.0/flower) on plants sprayed with leaf extract mixtures of Neem + *Eucalyptus*, Neem + lemon grass, Neem + bitter leaf, Neem + tomato, and *Eucalyptus* + African curry (in that order) than on unsprayed plants. These extract mixtures also increased pod density per plant compared with the unsprayed plants in the two years of investigation. The synergistic attributes of some plant extracts in mixtures with those of other plant species could form the basis of bio-pesticides formulations for resource-limited farmers in low input agriculture in the developing countries.

The common method for controlling of this pest infestation in Bangladesh is the application of chemical insecticides. Control of insect pests by the routine use of chemical insecticides create several problems in agro-ecosystem such as direct toxicity to the beneficial insects, fishes and human and increased environmental and social costs (Pimetel, 1980). Botanical insecticides are broad-spectrum in action safe to apply and can easily be processed. Locally available plant materials have been widely used to protect field and stored products against insect infestation.

2.4Botanicals to control insect pest of yard long bean:

Khatun *et al.*,(2020).Conducted an experiment to find out less hazardous, environmental friendly and locally available botanicals to control bean aphid. Seven plant extracts viz., neem leaves (*Azadirachta indica*), lemon outer shell (*Citrus aurantifolia*), wild sunflower (*Helianthus petiolaris*), water gourd (*Lageneria siceraria*), green mango (*Mangifera indica*), bitter gourd (*Momordica charanter),* fire tree (*Delonix regia*) and detergent (5 g trix/L) were prepared to control the aphid infestation in yard long bean (variety kagarnatki) in the field. About 100 g of fresh plant parts of each were boiled in one liter of water at 550C for 5 minutes. Then rest the sample for one hour. The solutions were filtered and kept in clean glass bottles. The extract was kept in refrigerator at 40C until use. Then the extracts were sprayed at

an interval of 3 days in the experimental field of yard long bean. The damage potential of aphid was counted at every 3 days in a week. Results of this study showed that plant extracts were effective against aphid infestation in yard long bean. Similarly, yield results corresponded positively with the effectiveness of the treatments. In this study, fire tree &water gourd treatment showed 95- 98% control of yard long bean aphid, whereas a high number of aphids were found in the bitter gourd treatment (21.27±5.985278). Fire tree and water gourd treatment kept about 21.27 times better performance than that of bitter gourd treatment. Water gourd and fire tree has antibacterial, antifungal, antimicrobial properties and toxic activity to control insect pests. So, the present finding suggests that the use of plant extracts of fire tree and water gourd treatment to be very effective botanicals to control aphids of yard long bean in Bangladesh.

Ramesh*et al.,* (2019) carried out an investigation to know the seasonal incidence of aphids and their level of infestation on yard long bean. The short duration yard long bean variety Arka Mangala was found infested with many number of sucking pests at various stages of crop growth. Among the different sucking pests recorded on yard long bean, aphids, *Aphis craccivora* Koch was the major pest causing yield loss under open field condition. The incidence of aphid was noticed throughout the cropping period. During *Kharif* the aphid population ranged from 2.82 *to* 72.37 aphids per leaf. Whereas during *Rabi* the aphid population ranged from 1.20 to 79.57 aphids per leaf. During *Kharif* the incidence of aphids was significant and positively correlated with the maximum temperature, maximum relative humidity and minimum relative humidity. Whereas, minimum temperature and rainfall showed a significant and negative correlation with aphid population. During *Rabi*, it was significant and positively correlated with the maximum and minimum temperature, rainfall and maximum relative humidity. Whereas, minimum relative humidity shows a non-significant negative correlation with the aphid population.

Ali *et al.*,(2019) demonstratyed that the highest number of leaves was found in Beal leaf treatment (78.57±0.600a) while the least amount of leaves was in Mahogany treatment (17.166±0.970e) Fuchs (1970) reported that nutrients from mineral fertilizers and bio-pesticides enhanced the establishment of crops while those from the mineralization of organic matter promoted yield. The tallest yard long bean plant was observed in the treatment of Halude hurhuri (160.67±6.06 cm) Neem

(129.66±10.17cm) and Beal leaf (125.33±14.57 cm) while the shortest plant was in the treatment of Mahogany (55.04±7.18 cm). The vigorous growth in Yard long bean was experienced during the growing period as evidenced in the vine length and number of leaves produced per plant. Nutrients from mineral fertilizers and bio-pesticides enhanced the establishment of crops while those from the mineralization of organic matter promoted yield.

Srinivassan*et al.,* (2015) revealed that seed kernel extracts of China berry (*Melia azedarach*) against oriental fruit fly (*Bactrocera dorsalis*) and tomato fruit borer (*Helicoverpa armigera*), and commercial neem formulations containing azadirachtin (Biofree-I® and Thai neem 111®) against the legume pod borer (*Maruca vitrata*) were tested in Taiwan and Thailand to confirm their effects on oviposition, feeding, growth and development. Various extracts from *M. azedarach* seed kernels significantly reduced the oviposition of *B. dorsalis* and the efficacy was similar to Bio free-I. The green drupe and dry seed kernel extracts of *M. azedarach* substantially increased larval mortality, and reduced successful pupation, pupal weight, adult emergence, fecundity and egg hatch of *H. armigera* larvae. Commercial neem formulations exhibited adverse morphogenic effects on various biological parameters of *M. vitrata*, but they did not reduce oviposition and egg hatch. *M. azedarach* extracts and commercial neem formulations can be employed together for the sustainable management of *B. dorsalis*, *H. armigera* and *M. vitrata*.

The survey was took place in intensive yard long bean growing areas such as Jessore, Dhaka, Narsingdi, Comilla and Chittagong of Bangladesh to know the pest incidence and their level of infestation on yard long bean. The study comprised of 75 sample farmers through intensive field visit for field data collection and inspection. Pest complex of yard long bean and their intensity of incidence were more or less similar in five surveyed areas and there were at least nine out of ten insect pests at different growth stages in each sample area, which were aphid, pod borer, thrips, red mite, leaf miner, leaf beetle, green sting-bug, jute hairy caterpillar, hooded hopper and semilooperin descending order. It was revealed that aphid and pod borer were the major insect pests in the study areas. They were found to severely infest in yard long beans. Semilooper caused minor damage which occurred only in Jessore, Chandina and Mirshawrai sample areas (Uddin*et al.*, 2013)

Bahar *et al*., (2007) demonstrated that effect of five different botanical extracts-tobacco, neem, garlic, eucalyptus and mahogany-on aphid population. Aphids were deliberately exposed to the above botanical extracts and then the numbers of live and dead aphids were counted. The botanical extracts showed significant effect on the numbers of live aphids. Tobacco leaf extract had inflicted consistently the maximum level of aphid mortality; about 74-90% of the aphids were killed by the treatment in different conditions. Killing about 53-64% of the aphids on treated plants, the extract of neem followed the extract of tobacco. Garlic extract showed similar performance to that of neem. Eucalyptus and mahogany reduced aphid population. Contrasting to the case with aphid numbers, the botanical extracts did not affect the most common and recognized predators, ladybird beetles in the laboratory. Botanical extracts had significant effects on yield of yard long beans. Tobacco extract treated plants produced the greatest number, amount and biomass of yard-long beans; the treatment was followed by neem and garlic. The latter two treatments did not show significant effect.

The use of conventional insecticides has raised some concern about their threat to the environment (Huang *et al.,* 1998). Therefore, there is an imperative need for the development of safer, alternative crop protectants such as botanical insecticides. Current pest control technology is based largely on imported synthetic insecticides, which are frequently priced beyond the small farmers, who constitute a very large proportion of the farming population in Bangladesh. Moreover, many insects been reported to be resistance to chemical insecticides (Halliday *et al*., 1988). This problem has increased the need for effective and biodegradable pesticides with greater selectivity. Bangladesh and many other Asian countries are rich in plant products and traditionally used by the rural inhabitants for medicinal purpose and in some instance as preparations for insect control (Talukdar and Howse, 1993). Botanical insecticides tend to have broad spectrum activity, are relatively specific in their mode of action, and easy to process and use in farm-levels. They are also safe for higher animals and the environment (Anonymous, 1991). Botanical insecticides can often be easily produced by farmers and small-scale industries with indigenous plant materials. These are cheaper and hazard free in comparison to chemical insecticides (Saxena *et al*., 1980). Plants are rich sources of natural substances that can be utilized in the development of environmentally safe methods for insect control (Sadek, 2003).

CHAPTER III

MATERIALS AND METHODS

The experiment took place in the central farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2018 to March, 2019 for the exploration of major insect pest of yard long bean and their eco-friendly management by using some botanicals. Required adopted materials and methodology are described below under the following sub-head.

3.1 Description of the experimental site

3.1.1 Experimental period

The field experiment was conducted from November, 2018 to March, 2019.

3.1.2 Location

The experiment was held in the central farm of Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207.The location of the site is $23^{0}74^{/}$ N latitude and $90^{0}35^{/}$ E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

3.1.5 Characteristics of soil in the experimental field

The soil texture of the experimental sit is the medium high Land clay loam which belong to the Madhupur tract (AEZ-28).The soil of the site is shallow red brown and the soil series was Tejgaon(Appendix II).

.3.1.4 Weather condition of the experimental site

The climatic state of experimental site is subtropical and represented 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 or rainy season from May to October. The average maximum and minimum temperature were 28.10ºC and 19.20º C respectively during the experimental period (Appendix III).

Plate 1: Photograph showing experimental plot during the study period

3.2 Experimental details

3.2.1 Planting material

For the experiment the seeds of BARI yard long bean-1 were used as the test crop. The seeds of the test crop were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.2.2 Treatment of the experiment

The experiment was conducted with six treatments and one untreated control of the bio-pesticides –

T_1=Garlic bulb extract @ 5ml/L of water at 7 days interval

T_2: Neem leaf extract @ 5 ml per liter of water at 7 days interval

T_3: Datura seeds extract @ 5 ml per liter of water at 7 days interval

T_4: Black pepper seed extract @ 5ml per liter of water at an interval of 7 days interval

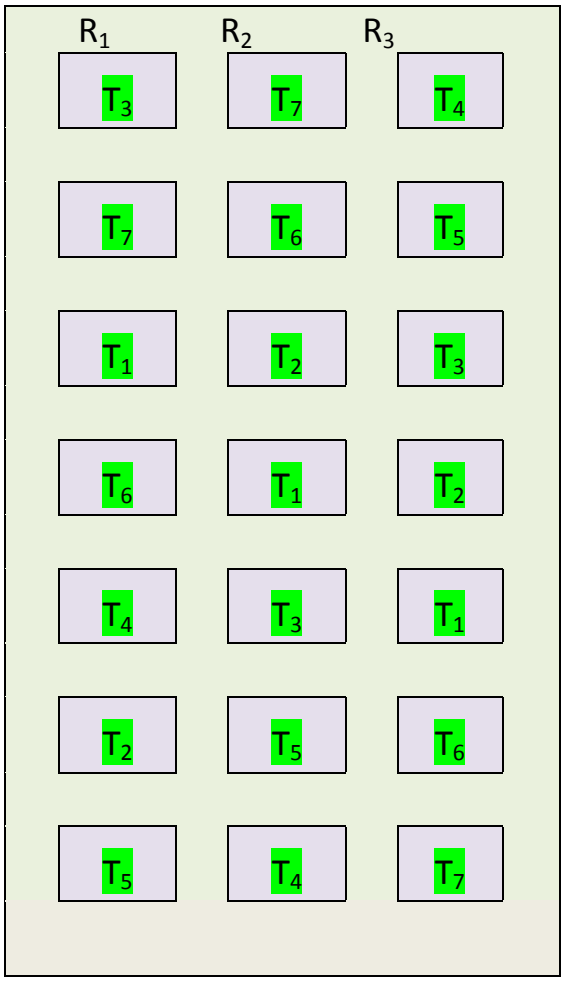
T_5: Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days interval

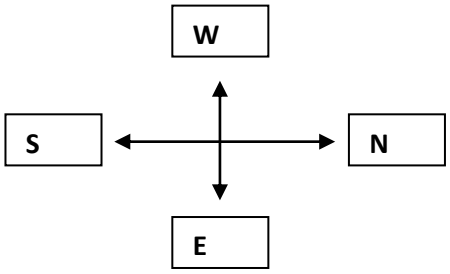
T_6: Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days intervals

T_7: Untreated control.

3.2.3 Experimental design and layout

The experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications, where the experimental area was separated into three equal blocks representing the replications to minimize the soil heterogenetic effects. Each block was divided into 7 even unit plots where 7 treatments were allocated at random. Thus the total numbers of plots were 21. The unit plot size was 3.5m × 2 m. (Plate 1.) The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.





Treatments:

T_1=Garlic bulb extract @ 5ml/L of water at 7 days interval
T_2=Neem leaves extract @ 5ml/L of water at 7 days interval
T_3=. Datura seeds extract @ 5ml/L of waterat 7 days interval
T_4= Black pepper seed extract @ 5ml/L of waterat 7 days interval
T_5= Mahogany seed extract @ 5ml/L of waterat 7 days interval
T_6=Tobacco leaf extract @ 5ml/L of waterat 7 days interval
T_7= Untreated Control
Plot size: **(**3.5 X 2) m^2

Figure 1. Layout of experimental plot

[Plot to plot distance = 0.5 m; Block to block distance = 1 m and No. of Replication = 3]

3.3 Growing crop

3.3.1 Land preparation

The main plot which select for conducting the experiment was opened in the 1st week of November, 2018 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed accordingly. The experimental main plot was partitioned into unit plots in accordance with the experimental design.

3.3.4 Fertilizers and manure application

Standard dosages of cow dung and fertilizers were applied as recommended by Rashid (1993) for yard long bean @ 12 kg of cow dung, 60 g urea, 100 g TSP and 100 g MP respectively per pit of each plot. Again 30 g urea was applied as top dressing after each flush of flowering and fruiting in three equal splits.

3.3.5 Raising of seedlings

The seeds of yard long bean were soaked for 12 hours in water. Seeds were directly sown in the 12th November, 2018 in the pit of the main field containing a mixture of equal proportion of well decomposed cow dung and irrigated regularly to bring moist condition for proper seed germination. After germination the seedlings were sprayed with water by a hand sprayer for easy uprooting and it was done once a day for one week.

3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. The following intercultural operations were done.

3.3.6.1 Irrigation and drainage

Irrigation was provided to maintain moist condition in the early stages to establishment of the seedlings and then irrigated whenever necessary throughout the entire growing period. No water stress was encountered in reproductive phase. Proper drainage facilities were made for drainage of excess water.

3.3.6.2 Weeding: Weeding were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully. It also helped to suppress the infestation level of insects.

3.3.6.3 Assembling of treatment materials:

The dried tobacco leaf, garlic cloves, black paper were collected from the local market of Agargaon bazar. Plant leaves and seeds were collected from different places of SAU. Before grinding or cutting, the leaves and seeds were dried up.

3.4 Preparation of botanical extracts

3.4.1Garlic bulb extract

For the preparation of Garlic bulb extract;

- Fresh garlic bulbs were collected from the local market of Agargaon bazaar. and chopped the bulbs in small size by sharp knife.
- 250 gm chopped garlic bulbs were taken into electric blender for blending in order to get fine pest.
- Theblendedgarlicwastakenintothebeakerand250mlwaterwasaddedwith thegarlicextract.
- Thebeakerwasstirredfor30minuteswiththemagneticstirrerto make the extracts of garlic.

The aqueous extract then filtered using Whatman no.1 filter paperand preserved the aqueous extracts of garlic in cool temperature.

3.4.2 Neem leaves extract

For the preparation of neem leaf extract,

- The leaves of neem used for the experiment was collected from trees in SAU campus and they were washed in running tap water.
- Firstly, the plant materials were kept in the shade for air-drying and then dried in the oven at 60^0 C to gain constant weight.
- Dusts were prepared by pulverizing the dried leaves with the help of a grinder. Then dusts were passed through a 0.66 mm diameter sieve to obtain fine dusts. The dusts were preserved in airtight condition in polythene bags.

- 250gm dried neem leaf powder was mixed with 250 ml water. It was stirred with the magnetic stirrer for 30 minutes to make the extracts of neem leaves

The aqueous extract then filtered using Whatman no. 1 paperfilter andwere used mixed with one drop of fragrance-free liquid detergent was added as a surfactant and spreading agent before spraying.

3.4.3 Datura seeds extract

For the preparation of Datura seeds extract;

- The mature datura seeds were collected from the datura plant found in the campus of SAU.
- Then seeds were roasted at 60 ^{0}C for 1 to 2 days by electric oven. Then the seed kernel was separated and taken into the electric grinder for grinding.
- 250 gm of datura seed powder was taken into a beaker and 250 ml water was added into it. It was stirred with the magnetic stirrer for 30 minutes to make the extracts of neem leaves.

The aqueous mixture then filtered using Whatman no. 1 filterpaper and stored in cool temperature.

3.4.4 Black pepper seed extract

For the preparation of Black pepper seed extract;

- The fresh black pepper seeds were collected from the local market of Agargaon bazar.
- Seeds werecrashedusingelectric-grinder, in order to get fine powder.
- 250gm dried black pepper powder was taken into a 500 ml beaker. 250 ml water was taken into the beaker and then the beaker was starred for 30 minutes with the magnetic stirrer to make the extracts of black pepper.

The aqueous extract then filtered using Whatman no. 1 filter paperand was stored in cool temperature.

3.4.5Mahogany seed extract

For the preparation of Mahogany seed extract;

- The mature and dried mahogany seeds were collected from the mahogany

tree found in the SAU campus.

- Seeds were roasted at 60ºC to 80ºC for 1 to 2 days by electric oven. Then the seed kernel was separated and taken into the electric blender for blending.
- 250 gm of this powder was taken into a beaker and 250 ml water was added into it. Then the beaker was stirred by electric stirrer for 30 minutes thoroughly to prepare mahogany seed extract.

The aqueous mixture then filtered using Whatman no. 1 filter paper and preserved the aqueous extracts in the refrigerator at 4^0c for future experimental use.

3.4.6 Tobacco leaf extract

For the preparation ofTobacco leaf extract;

- Dried Tobacco leafwere collected from the local market of Agargaon bazar.
- After collection Tobacco leafwere washed with water and kept in the shade up to 1 days for air-drying.
- The dried leaves were ground separately with electrical grinder and sieving through 0.66 mm diameter sieve to obtain fine dusts. The dust was being preserved into plastic pot at low temperature.
- 250 gm of Tobacco leafpowder was taken into a beaker and 250 ml water was added into it. It was starred with the magnetic stirrer for 30 minutes to make the extracts of Tobacco leaf.

The aqueous mixture then filtered using Whatman no. 1 filterpaper and stored in cool temperature.

3.5 Procedure of spray application

3.5.1 Garlic bulb extract

For proper management of major insect pest of Yard long bean; 5 ml Garlic bulb extract was mixed with 1Litre of water and then one drop of fragrance-free liquid detergent was added. Which was added as a surfactant and spreading agent before spraying 3.5m x 2m area.

3.5.2Neem leaves extract: For proper management of major insect pest of Yard long bean; 5 ml neem leaves extract was mixed with 1Litre of water and one drop of

fragrance-free liquid detergent was added. Which was added as a surfactant and spreading agent before spraying 3.5m x 2m area.

3.5.3 Datura seeds extract

For proper management of major insect pest of Yard long bean; 5 ml datura seeds extract was mixed with 1Litre of water and then one drop of fragrance-free liquid detergent was added. Which was added as a surfactant and spreading agent before spraying 3.5m x 2m area.

3.5.4 Black pepper seed extract

For proper management of major insect pest of Yard long bean; 5 ml neem seed kernel extract was mixed with 1Litre of water and then one drop of fragrance-free liquid detergent was added. Which was added as a surfactant and spreading agent before spraying 3.5m x 2m area.

3.5.5 Mahogany seed extract

For proper management of major insect pest of Yard long bean; 5 ml Mahogany seed extract was mixed with 1Litre of water and then one drop of fragrance-free liquid detergent was added. It was added as a surfactant and spreading agent before spraying 3.5m x 2m area.

3.5.6 Tobacco leaf extract

For the management of major insect pest of Yard long bean; 5 ml Tobacco leaf extract was mixed with 1Litre of water and then one drop of fragrance-free liquid detergent was added. Which was added as a surfactant and spreading agent before spraying 3.5m x 2m area

3.6 Spray and Monitoring

Botanicals were sprayed in assigned plots and dosages by using Knapsack sprayer. The spraying was always done in the afternoon to avoid bright sunlight. The spray materials were applied uniformly to obtain complete coverage of whole plants of the assigned plots. Caution was taken to avoid any drift of the spray mixture to the adjacent plots at the time of the spray application. At each spray application the spray mixture was freshly prepared. The botanical solution was sprayed on yard long bean

experimental field once in a week with the help of a sprayer. The pest was monitored every day and damages were counted every 3days in a week.

3.7 Monitoring and data collection

The yard-long bean plants under different treatment were closely examined at regular intervals. The following data were collected during the period of the experiment.

- Incidence of insect pest
- Number of healthy pods
- Number of infested pods
- Pod infestation in number (%)
- Weight of healthy pods
- Weight of infested pods
- Pod infestation in weight (%)
- Number of inflorescence plant^{-1}
- Number of pods per plant
- Length of healthy pods (cm)
- Yield per plot (kg)
- Yield hectare^{-1} (ton)

3.8 Procedure of datacollection

3.8.1 Incidence of insects

All of the 6 plants of each plot carefully observed for the identification of attacking insect pests. All of them counted and recorded the collected data. The collected data were divided into different development stage.

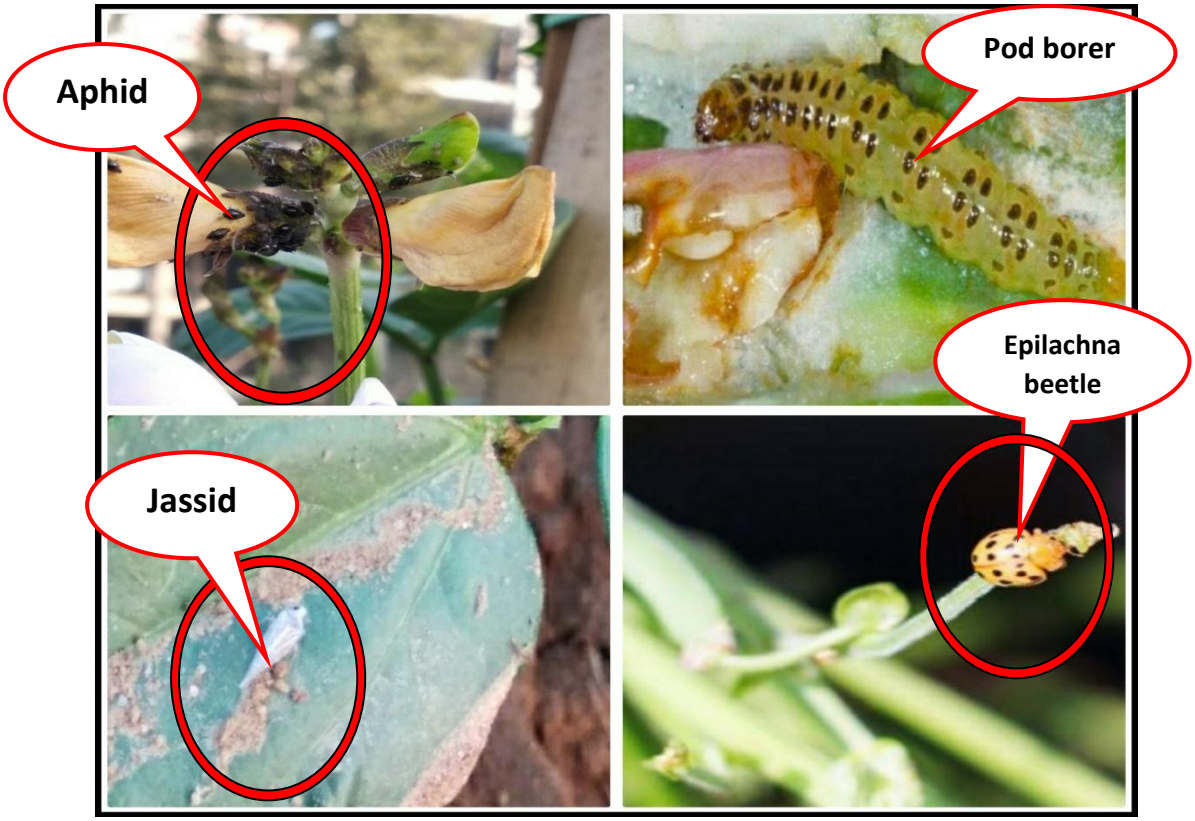


Plate 3.Insect incidence in experimental plot during the study period

3.8.2 Counting of insects

The effectiveness of each treatment in reducing selected insect under the present study infestation was evaluated on the basis of some pre-selected parameters. The following parameters were considered during data collection. Data were taken for aphid, jassid, epilachna beetle and pod borer from each plant. Aphid, jassid, were counted from top leaves of the plant. Epilachna beetle were counted from top leaves and branches of the plant. Pod borer were counted from the infested pod of yard long bean. Data on number of insects were recorded from first incidence and continued up to the harvest of the crop.

3.8.3 Number of healthy pods per selected plants

Number of healthy pods from each plot was counted and the mean number was expressed on per plant basis. The data were collected on different development stage. (Plate 4.)

Plate 4. Number of healthy pod in the experimental field

3.8.4 Number of infested pods

Number of infested pods from each plot was counted and the mean number was expressed on per selected plant basis. The data were collected on different stage (Plate 5 and Plate6).

Plate 5. Infested pod of yard long bean attacked by aphid at the untreated control plot in the experimental field

Plate 6. Infested pod of yard long bean attacked by epilachna beetle(A) and Infested inflorescences of yard long bean due to Aphids

3.8.5 Percent pod infestation by number

After harvesting the healthy pods and the infested pods were separated by visual observation. The number of healthy pods and infested pods were counted and the percent pods infestation for each treatment was calculated by using the following formula:

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

$$\% \text{ Reduction of infestation over control} = \frac{\text{(Infestation of control plots - infestation of treated plots)}}{\text{Infestation of controlplot}} \times 100$$

3.8.6 Weight of healthy pods per selected plants

Weight of infested pods of selected plants from each plot was recorded and the mean weight was expressed on per plant basis. The data were collected on different stages.

3.8.7 Weight of infested pods per selected plants

Weight of infested pods of selected plants from each plot was recorded and the mean weight was expressed on per plant basis. The data were collected during different stage.

3.8.8 Percent pod infestation by weight

After harvest at each fruiting stage, the total pods were sorted into healthy and infested once for each treatment. On the basis of weight of healthy pods and infested pods the percent pods infestation was calculated.

$$\%\text{Pod infestation (by weight)} = \frac{\text{Weight of infested pods}}{\text{Total weight of pods observed}} \times 100$$

$$\% \text{ Reduction of infestation over control} = \frac{\text{(Infestation of control plots - infestation of treated plots)}}{\text{Infestation of control plot}} \times 100$$

3.8.9 Number of inflorescence per selected plants

During the reproductive stage of the plant total numbers of inflorescences from each individual plot were recorded in each treatment.

3.8.10 Podlength

Pod length was taken of randomly selected pods from each treatment and the mean length was expressed on per pod basis.

3.8.11 Pod yield per plot

Total weight of collected pods of yard long bean from each plot was weighted and recorded and expressed in gram.

3.8.12 Pod yield per hectare

Pods yield of yard long bean per plot were converted into hectare and expressed yield in ton.

$$\% \text{ Increase of yield over control} = \frac{\text{Yield of treated plots – yield of control plots}}{\text{Yield of controlplot}} \times 100$$

3.9 Harvesting of pods

Harvesting of pods was done when the pods attained marketable sized**.** The optimum marketable sized pods were collected by hand picking of each plot and yield was converted into t/ha.

Plate 7. Photograph showing harvested healthy Yard-long bean during the study period

3.10 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the effects of different treatments. The mean values of all the characters were calculated and analysis of variance was performed by using Statistics 10 software. The significance of the difference among the treatments means was estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted to find out the suitable botanical pesticides to manage insect on yard long bean. Data on number of insect, number and weight of healthy pod, infested pod and percentage of pod infestation in number and weight basis and yield of yard long bean were recorded. The analyses of variance (ANOVA) of the data on different recorded parameters are presented in **Appendix IV-XIV.**The findings have been presented and discussed, and possible discussions have been given under the following headings and sub-headings:

4.1 Insect pest incidence

Incidence of major insect pests of yard long bean was observed for the entire cropping season. Insect pests from each plant during the vegetative and reproductive stage was counted.Reproductive stage which was divided in to early, mid and late stages depending on the duration of reproductive stage to investigate the performance of different treatments.

4.1.1 Vegetativestage

Statistically significant variation was recorded for aphid and jassid due to different management practices **(Table 1).** In case of aphid, the lowest number per selected plants (3.39) was found from T_6 (Tobacco leaf Extract @ 5ml/L of waterat 7 days interval) which was statistically significant with (3.99) T_2 (Neem leaves extract @ 5ml/L of water at 7 days interval) and (4.61) with T_1 (Garlic bulb extract @ 5ml/L of water at 7 days interval). On the other hand, the highest number of aphid was recorded in (9.83**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (6.55 and 5.72) by T_4 (Black pepper seed extract @ 5ml/L of waterat 7 days interval) and T_3 (Datura seeds extract @ 5ml/L of waterat 7 days interval) and closely followed by (4.99) T_5 (Mahogany seed extract @ 5ml/L of waterat 7 days interval).

In case of jassid, the lowest number per selected plants (0.33) was found from T_6 (Tobacco leaf Extract @ 5ml/L of waterat 7 days interval) which was statistically significant with (0.72) T_2 (Neem leaves extract @ 5ml/L of water at 7 days interval) and (1.05) with T_1 (Garlic bulb extract @ 5ml/L of water at 7 days interval). On the

other hand, the highest number of jassid, was recorded in (1.83**)** T_7 (Untreated Control) which was statistically different from all other treatments followed by (1.72 and 1.61) by T_4 (Black pepper seed extract @ 5ml/L of waterat 7 days interval) and T_3 (Datura seeds extract @ 5ml/L of waterat 7 days interval) and closely followed by (1.55) T_5 (Mahogany seed extract @ 5ml/L of waterat 7 days interval).

In case of healthy leaves perselected plants, the highest number was observed from T_6 (25.44) which was statistically significant with T_2 (23.11) and T_1 (20.39) and closely followed by T_5 (19.11) and T_3 (18.16) and followed by T_4 (17.83), whereas the lowest number was observed from T_7 (16.83) treatment. In case of infested leaves perselected plants, the lowest number was observed from T_6 (1.05) which was statistically significant with T_2 (1.66) and T_1 (2.16) and closely followed by T_5 (2.83) and T_3 (3.33) and followed by T_4 (4.00), whereas the highest number was observed from T_7 (4.83) treatment.

Aphid attack plant stems, buds, leaves, flowers and pods of the plants. Both nymphs and adults of aphid and jassid suck cell sap of infested plants while feeding they inject a toxin along with the salivary secretion into host plants (Srivastava and Singh, 1986).

Table 1.Incidence of insect pests at the vegetative stage of yard long bean

Treatments	At vegetative stage				
	No. of aphid / 5plants	**No. of jassid /5 plants**	**No. of healthy leaves /plant**	**No. of infested leaves / plant**	**% of Infestation**
T_1	4.61 d	1.05 c	20.39 c	2.16 e	9.59 e
T_2	3.99 e	0.72 d	23.11 b	1.66 f	6.81 f
T_3	5.72 c	1.61 b	18.16 de	3.33 c	15.05
T_4	6.55 b	1.72 ab	17.83 de	4.00 b	18.71
T_5	4.99 d	1.55 b	19.11 cd	2.83 d	12.83
T_6	3.39 f	0.33 e	25.44 a	1.05 g	3.76
T_7	9.83 a	1.83 a	16.83 e	4.83 a	22.29
LSD(0.05)	0.455	0.215	2.097	0.3001	1.308
CV (%)	4.58	9.60	5.86	5.97	5.78

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.1.2 Early pod formation stage of yard long bean

Statistically significant variation was found at early stage aphid as major insect pests of yard long bean (Table 2). In case of aphid, the lowest number per selected plants(7.55) was recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (9.27) fromT_2 (Neem leaf extract @ 5 ml/L of water) and (10.88) T_1 (Garlic bulb extract @ 5 ml/L of water), whereas the highest number (21.88) was found from T_7(Untreated control) which was significantly followed by (13.607) T_4 (Black paper seed extract @ 5 ml/L of water).

Table 2. Effect of different botanicals against insect pestsof yard long bean at early pod development stage (By number)

Treatment	No. of Aphid / 5 plants	No. of Jassid / 5 plants	No. of Pod borer / 5 plants	No. of Epilachna beetle / 5 plants
T_1	10.88 c	6.67 d	3.606 d	3.16 d
T_2	9.27 d	4.99 e	2.55 e	2.16 e
T_3	13.33 b	10.20 b	4.94 c	5.16 b
T_4	13.607 b	10.83 b	6.21 b	5.22 b
T_5	12.49 b	8.83 c	4.44 c	4.55 c
T_6	7.55 e	3.55 f	0.89 f	0.33 f
T_7	21.88 a	18.16 a	11.44 a	8.88 a
LSD $_{(0.05)}$	1.1834	0.8133	0.7015	0.5417
CV (%)	5.23	5.05	8.10	7.23

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

For jassid infestation, there was a significant variation found at early stage of yard long bean (**Table 2**). The findings showed that infestation of Jassid, the lowest number per selected plants(3.55) T_6 was recorded from (Tobacco leaf extract @ 5 ml/L of water) followed by (4.99) T_2 (Neem leaf extract @ 5 ml/L of water) and (6.77) T_1 (Garlic bulb extract @ 5 ml/L of water), whereas the highest number (18.16) was found from T_7(Untreated control) which was significantly followed by (10.83) T_4 (Black paper seed extract @ 5 ml/L of water).

In case of pod borer, the lowest number per selected plants(0.89) was recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (2.55) T_2 (Neem leaf extract

@ 5 ml/L of water) whereas the highest number (11.44) was found from T_7 (Untreated control) which was significantly followed by (6.21) T_4 (Black paper seed extract @ 5 ml/L of water).

Again, considering the number of Epilachna beetle, lowest number of insect (0.33) was found with the treatment of T_6 (Tobacco leaf extract @ 5 ml/L of water) and (2.16) T_2 (Neem leaf extract @ 5 ml/L of water) whereas the highest number (8.88) was found from T_7 (Untreated control) which was significantly followed by (5.22) T_4 (Black paper seed extract @ 5 ml/L of water).

4.1.3 Mid pod stage

At mid pod stage of yard long bean, significant variation was showed in aphid infestation of yard long bean (Table 3).The lowest number of aphid per selected plants(3.77) was recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (5.21) T_2 (Neem leaf extract @ 5 ml/L of water) and (6.71) T_1 (Garlic bulb extract @ 5 ml/L of water), whereas the highest number (28.16) was found from T_7(Untreated control) which was significantly followed by (8.94) T_4 (Black paper seed extract @ 5 ml/L of water).

Again, the experimental findings showed that at mid stage, jassid infestation of yard long bean varied significantly (**Table 3**). Result revealed that the lowest number per selected plants(2.88) was recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (4.21) T_2 (Neem leaf extract @ 5 ml/L of water) and (4.99) T_1 (Garlic bulb extract @ 5 ml/L of water), While the highest number (22.50) was found from T_7 (Untreated control) which was significantly followed by (7.83) T_4 (Black paper seed extract @ 5 ml/L of water).

In case of pod borer, the lowest number (2.50) was found from T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (4.27) T_2 (Neem leaf extract @ 5 ml/L of water) and (6.05) T_1 (Garlic bulb extract @ 5 ml/L of water), whereas the highest number of pod borer per plant (18.55) was found from T_7 (Untreated control) which was significantly followed by (7.83) T_4 (Black paper seed extract @ 5 ml/L of water).

Again, the lowest number of epilachna beetle (0.33) was observed by T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (2.16) T_2 (Neem leaf extract @ 5 ml/L of water) and (3.16) T_1 (Garlic bulb extract @ 5 ml/L of water), whereas the highest

number of pod borer per plant (8.88) was found from T_7 (Untreated control) which was significantly followed by (5.22) T_4 (Black paper seed extract @ 5 ml/L of water).

Table 3.Effect of different botanicals against insect pests of yard long bean at mid pod development stage (By number)

Treatment	No. of Aphid / 5 plants	No. of Jassid / 5 plants	No. of Pod borer / 5 plants	No. of Epilachna beetle / 5 plants
T_1	6.71 d	4.99 d	6.05 d	3.66 c
T_2	5.207 e	4.21 e	4.27 e	1.83 d
T_3	7.94 c	7.33 bc	7.83 c	5.16 b
T_4	8.94 b	7.83 b	9.05 b	5.2 b
T_5	7.82 c	6.38 c	7.71 c	4.94 b
T_6	3.77 f	2.88 f	2.5 f	0.77 e
T_7	28.16 a	22.5 a	18.55 a	14.05 a
LSD 0.05	0.8538	0.6271	0.9205	0.6218
CV (%)	4.90	4.36	6.47	6.95

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.1.4 Late pod developing stage

Yard long bean at late pod stage influenced in positively that applied of the experimental pesticide the number of attraction of aphid was decreased (**Table 4**). The lowest number of aphid per selected plants(8.83) was recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (11.99) T_2 (Neem leaf extract @ 5 ml/L of water), (14.11) T_1 (Garlic bulb extract @ 5 ml/L of water) and (15.27) T_5 (Mahogany seed extract @ 5 ml/L of water) while the highest number (25.99) was found from T_7 (Untreated control) followed by (16.66) T_4 (Black pepper seed extract@ 5 ml/L of water) and (16.33) T_3 (Datura seeds extract@ 5 ml/L of water).

On the other hand, the experimental treatments showed that at late stage of Jassid of yard long bean varied in statistically significant (Table 4). Result treated that the lowest number per selected plants(8.22) was recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (9.94) T_2 (Neem leaf extract @ 5 ml/L of water) and (11.27) T_1 (Garlic bulb extract @ 5 ml/L of water), while the highest number (23.38) was found from T_7 (Untreated control)followed by (15.11) T_4 (Black pepper seed extract@ 5 ml/L of water) and (14.66) T_3 (Datura seeds extract@ 5 ml/L of water).

In case of pod borer, the lowest number (0.77) was found from T_6 (Tobacco leaf extract @ 5 ml/L of water) followed by (2.33) T_2 (Neem leaf extract @ 5 ml/L of water) and (4.44) T_1 (Garlic bulb extract @ 5 ml/L of water), while the highest number (18.11) was found from T_7 (Untreated control)followed by (8.16) T_4 (Black pepper seed extract@ 5 ml/L of water) and (7.94) T_3 (Datura seeds extract@ 5 ml/L of water).

Again, considering the presence of epilachna beetle (0.22) epilachna beetle was found with the treatment of T_6 (Tobacco leaf extract @ 5 ml/L of water) and (2.00) T_2 (Neem leaf extract @ 5 ml/L of water) while the highest number (19.88) was found from T_7 (Untreated control)followed by (6.44) T_4 (Black pepper seed extract@ 5 ml/L of water) and (5.72) T_3 (Datura seeds extract@ 5 ml/L of water).

Table 4. Effect of different botanicals against insect pests of yard long bean at late pod development stage (By number)

Treatment	No. of Aphid / 5 plants	No. of Jassid / 5 plants	No. of Pod borer / 5 plants	No. of Epilachna beetle / 5 plants
T_1	14.107 d	11.27 d	4.44 c	3.55 d
T_2	11.99 e	9.94 e	2.33 d	2.00 e
T_3	16.33 bc	14.66 b	7.94 b	5.72 bc
T_4	16.66 b	15.11 b	8.16 b	6.44 b
T_5	15.27 cd	13.44 c	7.66 b	5.38 c
T_6	8.83 f	8.22 f	0.77 e	0.22 f
T_7	25.99 a	23.38 a	18.11 a	19.88 a
LSD 0.05	1.1715	0.8860	0.8794	0.8213
CV (%)	4.17	3.63	7.01	7.48

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.2Pod bearing status

4.2.1 At early pod development stage

4.2.1.1 Pod bearing status in number basis

Number of healthy and infested pods, infestation percentage at early pod development stage showed statistically significant differences due to different botanicals as treatments in controlling major insect pests of yard long bean (**Table 5**) at 70 days after planting.

The highest number of healthy pods per selected plants(11.44) was recorded from T_6 (Tobacco leaf extract @ 5 ml per liter of water) treatment which was statistically significant with (9.45 and 8.11) to T_2 (Neem leaf extract @ 5 ml per liter of water) and T_1 (Garlic bulb extract @ 5 ml per liter of water) and closely followed (6.66, 6.55 and 5.27) by T_5 (Mahogany seed extract @ 5 ml per liter of water), T_3 (Datura seeds extract @ 5 ml per liter of water) and T_4 (Black pepper seed extract @ 5ml per liter of water) treatment and they were statistically similar, whereas the lowest number of healthy pods per plant (5.05) was found from T_7 (untreated control) treatment.

The lowest number of infested pods per selected plantswas obtained from T_6 (0.94) treatment which was statistically similar to T_2 (1.21) treatment and closely followed by T_1 (1.38) and T_5 (1.61) treatment. On the other hand, the highest number of infested pods was obtained from T_7 (2.16) treatment which was followed by T_4 (1.71) and T_3 (1.66) treatment and they were statistically similar.

In relation to the percentage (%) of pods infestation, the lowest infested pods per plant in number was recorded from T_6 (7.63%) which was statistically different with T_2 (11.40%) and T_1 (14.63%), again the maximum infested pods were recorded in T_7 (29.99%)

Infestation of pod reduction over control in number was estimated and the highest value was found from the treatment T_6 (74.55%) which was followed by T_2 (61.99%), T_1 (51.21%) and T_5 (35.95%) treatments and the minimum reduction of pod infestation over control from T_4 (33.48%) followed by T_3 (18.34%) treatment.

Table 5. Effect of different botanicals for the management of yard long bean at early pod development stage in terms of pod per selected plants (by number)

Treatment	Pods by number			
	Healthy	Infested	% Infestation	Reduction % over control
T_1	8.11 c	1.38 c	14.63 d	51.21
T_2	9.45 b	1.21 c	11.40 d	61.99
T_3	6.66 d	1.66 b	19.95 c	33.48
T_4	5.27 e	1.71 b	24.49 b	18.34
T_5	6.77 d	1.606 b	19.21 c	35.95
T_6	11.44 a	0.94 d	7.63 e	74.55
T_7	5.05 e	2.16 a	29.99 a	---
$LSD_{(0.05)}$	0.05	0.05	0.05	---
Level of significance	0.8798	0.206	3.27	---
CV %	6.59	7.58	10.05	---

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.2.1.2 Pod bearing status in weight basis

Statistically significant differences were recorded in terms of weight of healthy and infested pods and infestation percentage at early pod development stage due to different botanicals as treatments in controlling insect pest of yard long bean (**Table 6**).

In weight basis, the highest weight pods per selected plantswas recorded from T_6 (134.67 g) treatment which was statistically similar to T_2 (119.72 g) and T_1 (98.39 g) closely followed by T_5 (81.62 g) treatment, while the lowest weight of healthy pods per selected plants(58.94 g) was found from T_7 treatment closely followed by T_4 (68.94 g) treatment.

The lowest weight of infested pods per selected plantswas obtained from T_6 (5.15 g) treatment which was statistically significant to T_2 (7.44 g) treatment and closely followed by T_1 (9.88 g) treatment. On the other hand, the highest weight of infested pods was obtained from T_7 (18.76 g) treatment which was followed by T_4 (14.20 g) treatment.

In terms of percent pod infestation, the lowest infested pods per selected plantsin weight basis was observed from T_6 (3.69%) treatment which was statistically similar to T_2 (5.85%) and closely followed by T_1 (9.11%) treatment, again the highest infested pods (24.18%) was recorded in T_7 which was followed by T_4 (15.56%) and T_3 (13.52%) treatment and they were statistically similar.

Pod infestation reduction over control in weight basis was calculated and the highest value was found from the treatment T_6 (87.59%) which was statistically similar to T_2 (75.81%) and T_1 (62.33%) closely followed by T_5 (46.24%) treatment, while the lowest weight of healthy pods per plant was T_4 (29.36).

Table 6. Effect of different botanicals for the management of yard long bean at early pod development stage in terms of pod per selected plants (byweight)

Treatment	Pods by weight			
	Healthy	infested	% Infestation	Reduction % over control
T_1	98.39 c	9.88 c	9.107 d	62.33
T_2	119.72 b	7.44 d	5.85 e	75.81
T_3	78.27 de	12.32 b	13.60	43.76
T_4	68.94 e	14.20 b	17.08	29.36
T_5	81.62 d	12.20 b	13.00	46.24
T_6	134.67 a	5.15 e	3.00 f	87.59
T_7	58.94 e	18.76 a	24.18 a	---
LSD($_{0.05}$)	0.05	0.05	0.05	---
Level of significance	9.17	1.097	1.215	---
CV %	6.64	5.40	5.63	---

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.2.2 At mid pod development stage

4.2.2.1 Pod bearing status in number basis

Statistically significant variation was recorded in number of healthy and infested pods and infestation percentage at mid pod development stage for different botanicals as treatments in controlling insect pest of yard long bean (**Table 7**)at 90 days after planting.

The highest number of healthy pods per selected plantswas recorded from T_6 (20.27) treatment which was statistically significant to T_2 (18.83), T_1 (17.38) and T_5 (15.99) and closely followed by T_3 (15.61), while the lowest number of healthy pods per plant was found from T_7 (12.61) treatment which was statistically similar to T_4 (14.83).

The lowest number of infested pods per selected plantswas obtained from T_6 (0.89) treatment which was statistically similar to T_2 (1.21) treatment and closely followed by T_1 (1.49) treatment. On the other hand, the highest number of infested pods was obtained from T_7 (2.66) treatment which was followed by T_4 (1.83) and T_3 (1.71) treatment and they were statistically similar.

In terms of percent pod infestation, the lowest infested pods per selected plantsin number basis was observed from T_6 (4.19%) treatment which was statistically similar to T_2 (6.08%) and T_1 (7.91%) treatment and they were statistically similar, whereas the highest infested pods (17.44%) was recorded in T_7 which was followed by T_4 (10.98%) and T_3 (9.92%) treatment and they were statistically similar.

Pod infestation reduction over control in number was estimated and the highest value was found from the treatment T_6 (75.97%) which was statistically significant to T_2 (65.13%) and T_1 (54.64%) treatment and they were statistically similar, whereas the lowest reduction of pod infestation over control (37.04%) was recorded in T_4 which was followed by T_3 (43.12%) treatment and they were statistically similar.

Table 7. Effect of different botanicals for the management of yard long bean at mid pod development stage in terms of pod per selected plants (by number)

Treatment	Pods by number			
	Healthy	infested	% Infestation	Reduction % over control
T_1	17.38 c	1.49 c	7.91 c	54.64
T_2	18.83 b	1.22 d	6.08 d	65.13
T_3	15.61 d	1.72 bc	9.92 b	43.12
T_4	14.83 d	1.83 b	10.98 b	37.04
T_5	15.99 d	1.66 bc	9.41 b	46.03
T_6	20.27 a	0.88 e	4.19 e	75.97
T_7	12.61 e	2.66 a	17.44 a	---
$LSD_{(0.05)}$	1.187	0.25	1.198	---
CV %	4.04	8.87	7.15	---

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**.Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.2.2.2 Pod bearing status in weight basis

Weight of healthy and infested pods and infestation percentage at mid pod development stage showed statistically significant differences for different botanicals as treatments in controllinginsect pests of yard long bean (**Table 8**).

In weight basis, the highest weight pods per selected plantswas recorded from T_6 (297.83 g) treatment which was statistically similar significant to T_2 (277.16 g), T_1 (254.38 g), T_5 (240.61 g) and T_3 (233.66 g) treatment and closely followed by T_4 (210.67 g), while the lowest weight of healthy pods per selected plants(176.72 g) was found from T_7 treatment.

The lowest weight of infested pods per selected plantswas obtained from T_6 (24.55 g) treatment which was statistically significant to T_2 (27.94 g) treatment and closely followed by T_1 (30.99 g) treatment. On the other hand, the highest weight of infested pods was obtained from T_7 (48.55 g) treatment which was followed by T_4 (38.11 g) and T_3 (36.72 g) treatment and they were statistically similar.

Table 8. Effect of different botanicals for the management of yard long bean at mid pod development stage in terms of pod per selected plants (by weight)

Treatment	Pods by weight			
	Healthy	infested	% Infestation	Reduction % over control
T_1	254.38 c	30.99 d	10.87 d	49.58
T_2	277.16 b	27.94 e	9.16 e	57.51
T_3	233.66 d	36.72 bc	13.58 c	37.01
T_4	210.67 e	38.11 b	15.32 b	28.94
T_5	240.61cd	33.99 c	12.38 c	42.58
T_6	297.83 a	24.55 f	7.63 f	64.61
T_7	176.72 f	48.55 a	21.56 a	---
LSD($_{0.05}$)	17.30	2.785	1.2294	---
CV %	4.03	4.55	5.35	---

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

In terms of percent pod infestation, the lowest infested pods per selected plantsin weight basis was observed from T_6 (7.63%) treatment which was statistically similar significant to T_2 (9.16%) and closely followed by T_1 (10.87%) treatment, again the

highest infested pods (21.56%) was recorded in T_7 which was followed by T_4 (15.32%) and T_3 (13.58%) treatment and they were statistically similar.

Pod infestation reduction over control in weight basis was estimated and the highest value was found from the treatment T_6 (64.61%) which was followed by T_2 (57.51%), T_1 (49.58%) and T_5 (42.58%) treatments and the minimum reduction of pod infestation over control from T_4 (28.94%) followed by T_3 (37.01%) treatment.

4.2.3 At late pod development stage

4.2.3.1 Pod bearing status in number basis

Significant variation was observed in number of healthy pods, infested pods, percent of infestation and infestation reduction over control at late pod development stage by usingthe botanicals as treatments against the major insect pest of yard long bean (**Table 9**) at 110 days after planting.

The maximum number of healthy pods per selected plantswas recorded from T_6 (18.72) which was statistically different with T_2 (16.94) and T_1 (15.05) and followed by T_5 (13.44), while the least number of healthy pods was observed from T_7 (10.94) followed by T_4 (12.66) and T_3 (12.99) treatments.

On the other hand, the least number of infested pods per selected plantswas observed from T_6 (1.05) which was statistically different with T_2 (1.33) and closely followed by T_1 (1.60) and T_5 (1.72) treatments. In contemporary, the maximum number of infested pods was found from T_7 (2.11) followed by T_4 (1.83) and T_3 (1.77) treatment.

In relation to the percentage (%) of pods infestation, the least infested pods per selected plantsin number was observed from T_6 (5.33%) which was statistically different with T_2 (7.27%) and T_1 (9.65%) closely followed by T_5 (11.29%) and T_3 (11.99%) treatments, again the maximum infested pods were recorded in T_7 (16.14%) followed by T_4 (12.63%) treatment. Infestation of pod reduction over control in number was estimated and the highest value was found from the treatment T_6 (72.77%) which was followed by T_2 (61.78%), T_1 (47.35%) and T_5 (30.05%) treatments and the minimum reduction of pod infestation over control from T_4 (21.75%) followed by T_3 (25.71%) treatment.

Table 9. Effect of different botanicals for the management of yard long bean at late pod development stage in terms of pod per selected plants (by number)

Treatment	Pods by number			
	Healthy	infested	% Infestation	Reduction % over control
T_1	15.05 c	1.61 b	9.65 d	47.35
T_2	16.94 b	1.33 c	7.27 e	61.78
T_3	12.99 d	1.77 b	11.99 bc	25.71
T_4	12.66 d	1.83 b	12.63 b	21.75
T_5	13.44 d	1.71 b	11.29 c	30.05
T_6	18.72 a	1.05 d	5.33 f	72.77
T_7	10.94 e	2.11 a	16.14 a	---
$LSD_{(0.05)}$	1.10	0.2266	1.3049	---
CV %	3.95	7.81	6.90	---

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**.Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.2.3.2 Pod bearing status in weight basis

Significant variation was observed in weight of healthy pods, infested pods, percent of infestation and infestation reduction over control at late pod development stage. Use of botanicals for the management of major insect pest of yard long bean (**Table 10**) at 120 days after planting.

In context of healthy pods, the maximum weight per selected plants(255 g) was recorded from T_6 which was statistically different with T_2 (235.05 g) and closely followed by T_1 (221.89 g) and close to T_5 (212.00 g) treatments.On the other hand,

the minimum weight of healthy pods per selected plantswas recorded from T_7 (165.83 g) which was followed by T_4 (196.00 g) and close to T_3 (198.00 g) treatment.

Considering the infested pods, the weight of lowest infested pods per selected plantswas observed from T_6 (26.49 g) which was statistically significant with T_2 (30.72 g) and close to T_1 (33.61 g) and T_5 (36.83 g), while the weight of highest infested pods per selected plantswas found in T_7 (45.61 g) and closely followed by T_4 (37.77 g) and T_3 (37.55 g) treatment.

In relation to the percentage (%) of pod infestation in weight, the lowest infested pods per selected plantswas recorded from T_6 (9.40%) which was statistically similar with T_2 (11.57%) and closely followed by T_1 (13.17%) and T_5 (14.80%), whereas the highest weight of infested pods per selected plantswas observed in T_7 (21.58%) followed by T_4 (16.16%) and also followed by T_3 (15.94%) treatment.

In the basis of pod infestation reduction over control in weight per selected plantswas estimated and the highest value was obtained from the treatment T_6 (56.44%) which was statistically significant with T_2 (46.39%) closely followed by T_1 (38.97%), close to T_5 (31.42%), on the contrary, the lowest value from T_4 (25.12%) and followed by T_3 (26.14%) treatment.

Table 10. Effect of different botanicals for the management of yard long bean at late pod development stage in terms of pod per selected plants(by weight)

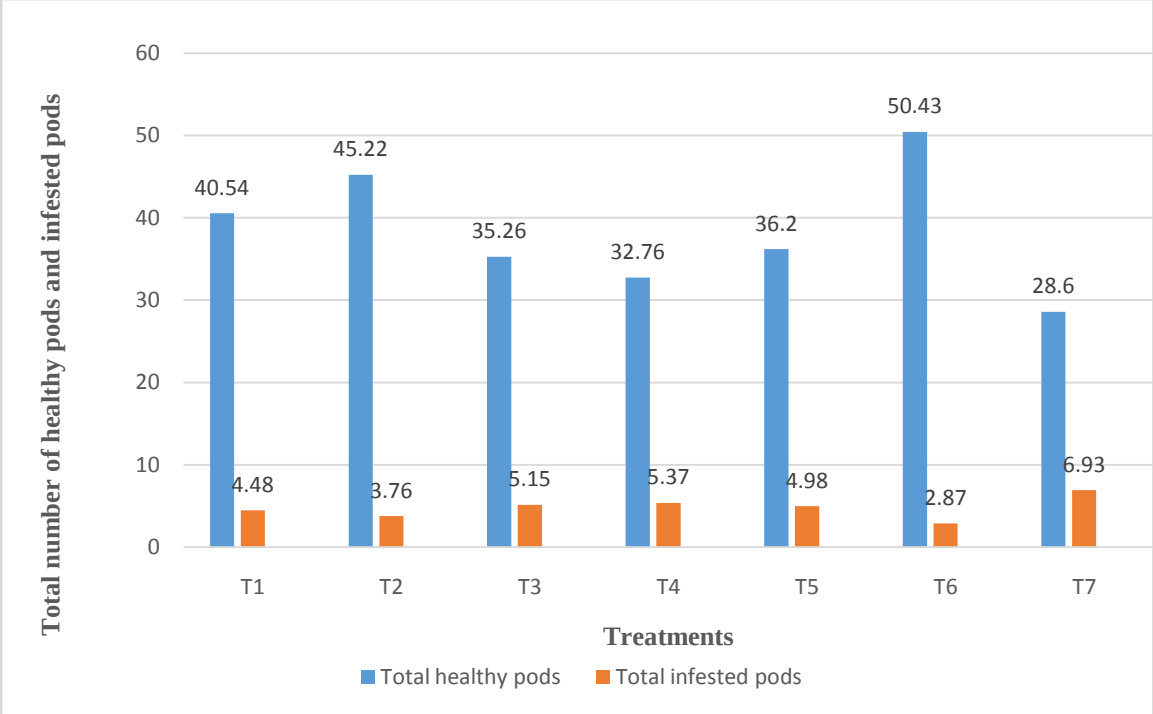
Treatment	Pods by weight			
	Healthy	infested	% Infestation	Reduction % over control
T_1	221.89 bc	33.61 c	13.17 c	38.97
T_2	235.05 b	30.72 c	11.57 d	46.39
T_3	198.00 d	37.55 b	15.94 b	26.14
T_4	196.00d	37.77 b	16.16 b	25.12
T_5	212.00 c	36.83 b	14.80 b	31.42
T_6	255.00 a	26.49 d	9.40 e	56.44
T_7	165.83 e	45.61 a	21.58 a	---
LSD($_{0.05}$)	14.29	3.108	1.25	---
CV %	3.79	4.92	4.79	---

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**.Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.3 Number of pods at total growing period

Significant variation was observed in number of total healthy pods, total infested pods at total growing period for the effect of different botanicals for the management of major insect pest of yard log bean (**Figure 2**).



[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and **T_7:** Untreated control.]

Figure 2: Effect of different botanicalson the number of total healthy pod and total infested Pod

In the term of total number of healthy pods perselected plants**,** the highest number per selected plantswas recordedT_6 (50.43) which was statistically different with T_2 (45.22) and T_1 (40.54) and followed by T_5 (36.2), while the least number of total healthy pods per selected plantswas observed from T_7 (28.6) followed by T_4 (32.76) and T_3 (35.26) treatments. On the other hand, the least number of total infested pods per selected plantswas observed from T_6 (2.87) which was statistically different with T_2 (3.76) and closely followed by T_1 (4.48) and T_5 (4.98) treatments. In contemporary, the maximum number of total infested pods was found from T_7 (6.93) followed by T_4 (5.37) and close to T_3 (5.15) treatment.

From the (**Figure 2)** it was observed that among the different treatments, T_6 (Tobacco leaf extract @ 5ml/L of water at 7 days interval) performed best in total pod bearing weight and total healthy pod weight and was more effective among different plant extract for the management of major insect pest of yard long bean. Whereas,

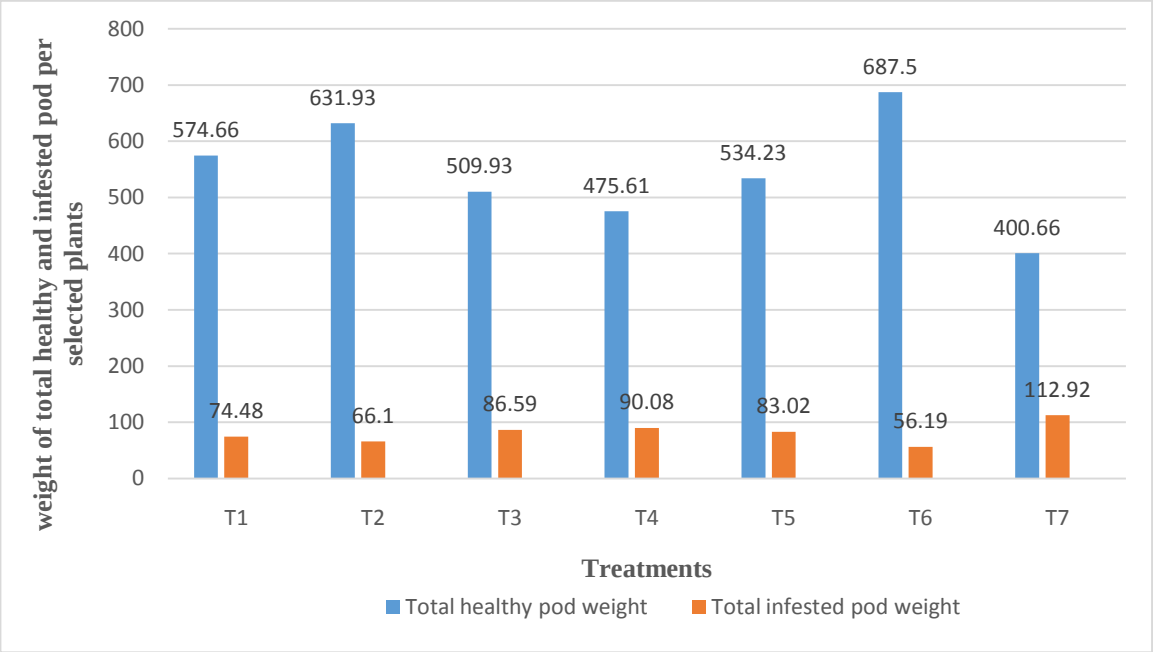
T_7(Untreated Control) showed the highest performance results in infestation of yard long bean. As a result, the order of rank of study the effect of different botanicals for the management of major insect pest of yard long bean by number was T_6> T_2> T_1> T_5 > T_3> T_4 > T_7.

4.5 Weight of pods at total growing period

Significant variation was observed in weight of total healthy pods, weight of total infested pods at total growing period for the effect of different botanicals for the management of major insect pest of yard log bean (**Figure 3**).

In the term of total healthy pods per selected plantswas recorded from T_6 (687.50 g) which was statistically different with T_2 (631.93 g) and T_1 (574.66 g) and followed by T_5 (534.23 g), while the minimum weight of total healthy pods was observed from T_7 (400.66 g) followed by T_4 (475.31 g) and T_3 (509.93 g) treatments. On the other hand, the lowest weight of total infested pods per plant was observed from T_6 (56.19 g) which was statistically different with T_2 (66.1 g) and closely followed by T_1 (74.48 g) and T_5 (83.02 g) treatments. In contemporary, the highest weight of total infested pods was found from T_7 (112.92 g) followed by T_4 (90.08 g) and close to T_3 (86.59 g) treatment.

From the (**Figure 3**)it was observed that among the different treatments, T_6 (Tobacco leaf extract @ 5ml/L of water at 7 days interval) performed best in total pod bearing weight and total healthy pod weight and was more effective among the of different botanicals for the management of major insect pest of yard long bean. Whereas, T_7 (Untreated Control) showed the highest performance results in infestation of yard long bean. As a result, the order of rank of study the efficacy of different botanicals for the management of major insect pest of yard long bean by number was T_6> T_2> T_1> T_5 > T_3> T_4 > T_7.



[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6.**Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and **T_7:** Untreated control.]

Figure 3: Effect of different botanicals on the weight of total healthy pod and total infested Pod

4.5 Yield contributing characters and yield of yard long bean

4.5.1 Number of Inflorescence per selected plants

Statistically significant variation was observed in number of inflorescence per selected plantsat different development stage for the effect of different botanicals for the management of major insect pest of yard long bean(**Table 11**).

The highest number of inflorescence per selected plantswas recorded from T_6 (48.33) which was statistically similar with T_2 (45.00), closely followed by T_1 (42.33) and close to T_5 (37.33) and followed by T_3 (35.00) while the lowest number was recorded from T_7 (27.33) and followed by T_4 (33.00) treatments.As a result, the order of rank of study the effect of different botanicals for the management of major insect pest of yard long bean by number was $T_6 > T_2 > T_1 > T_5 > T_3 > T_4 > T_7$.

4.5.2 Number of pods plant

Data revealed that number of pod per selected plantsof yard long bean showed statistically significant variation for the effect of different botanicals for the management of major insect pest of yard long bean (**Table 11**).

In the term of total number of bean pods per plant**,** the highest number per plant was recordedT_6 (73.22) which was statistically different with T_2 (65.49) and T_1 (62.90) and followed by T_5 (60.39), while the least number of total bean pods per selected plantswas observed from T_7 (49.16) followed by T_4 (58.61) and T_3 (59.66) treatments. As a result, the order of rank of study theeffect of different botanicals for the management of major insect pest of yard long beanby number was T_6> T_2> T_1> T_5 > T_3> T_4 > T_7.

4.5.3 Pod length

Data revealed that number of pod per selected plantsof yard long bean showed statistically significant variation for the effect of different botanicals for the management of major insect pest of yard long bean (**Table 11**).

In the term of pod length, the longest pod was recorded from T_6 (46.94 cm) which was statistically identical with T_2 (44.92 cm), closely followed by T_1 (42.81 cm) and close to T_5 (42.18 cm) and followed by T_3 (40.61 cm) while the minimum number was recorded from T_7 (35.93 cm) and followed by T_4 (40.33 cm) treatments. As a result, the order of rank of study the effect of different botanicals for the management of major insect pest of yard log bean by number was T_6> T_2> T_1> T_5 > T_3> T_4 > T_7.

Table 11. Effect of different botanicals on number of inflorescence, number of pod and pod length per selected plantsof yard long bean

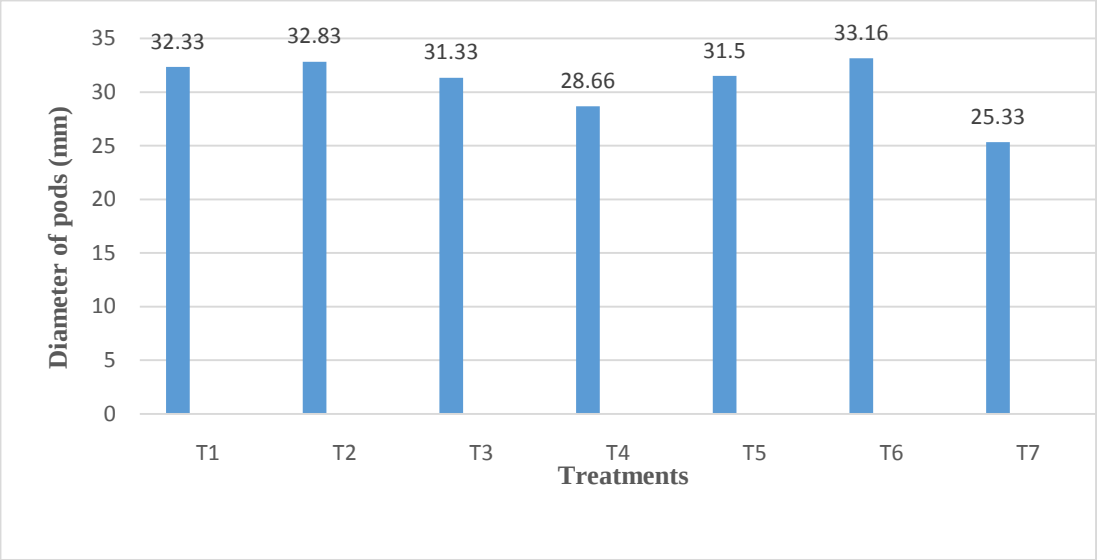
Treatments	Number of inflorescence per selected plants	Number of pods per selected plants	Pod length (cm)
T_1	42.33 b	45.02 bc	42.81 ab
T_2	45.00 ab	48.98 b	44.92 ab
T_3	35.00 c	40.41 cd	40.61 bc
T_4	33.00 c	38.13 de	40.33 bc
T_5	37.33 c	41.18 cd	42.18 b
T_6	48.33 a	53.3 a	46.94 a
T_7	27.33 d	35.53 e	35.93 c
LSD(0.05)	4.97	6.28	4.75
CV (%)	7.29	4.32	6.37

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

4.5.4 Diameter of healthy pod

Statistically significant variation was recorded in terms of diameter of healthy pod of yard long bean for different botanicals in controlling major insect pests of yard log bean (**Figure 4**). The highest diameter of healthy pod was found from T_6 (33.16 mm) which was statistically similar with other treatments except T_7, while the shortest was recorded from T_7 (25.33 mm) treatment.



[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and **T_7:** Untreated control.]

Figure 4: Effect of different botanicals on diameter of healthy pod of yard long bean

4.5.5 Yield per plot

Statistically significant variation was recorded for yield per plot of yard long bean for the use of different botanicals for the management of major insect pest of yard long bean (Table 12).

The highest yield per plot was observed from T_6 (11.60 kg) which was statistically similar with T_2 (10.98 kg), closely followed by T_1 (10.27 kg) and close to T_5 (9.99 kg) and followed by T_3 (9.63 kg) while the lowest yield per plot was recorded from T_7 (8.11 kg) and identically followed by T_4 (8.97 kg) treatments.

From the findings it is stated that spraying of Tobacco leaf extract @ 5ml/L of water at 7 days interval was more effective among the management practices for yield per plotwhich was followed by spraying of Neem leaf extract @ 5ml/L of waterat 7 days interval and Garlic bulb extract @ 5ml/L of water at 7 days interval that leads to the production of highest yield.

4.5.6 Yield of pods per hectare

The use of different botanicals for the management of major insect pest of yard long

bean showed statistically significant variation in terms of yield per hectare of yard long bean (Table 12).

The highest yield per hectare was found from T_6 (16.57 ton) which was statistically similar with T_2 (15.68 ton), closely followed by T_1 (14.68 ton) and close to T_5 (14.26 ton) and followed by T_3 (13.77 ton) while the lowest yield per hectare was recorded from T_7 (11.60 ton) and identically followed by T_4 (12.77 ton) treatments. Pod yield increase over control was estimated and the highest value was obtained from the treatment T_6 (42.84%) which was followed by T_2 (35.17%) close to T_1 (26.55%) and T_5 (22.93%) treatments and the minimum yield increase over control from T_4 (10.09 %) followed by T_3 (18.71%) treatment. As a result, the order of rank of study theeffect of different botanicals for the management of major insect pest of yard log beanby number was $T_6 > T_2 > T_1 > T_5 > T_3 > T_4 > T_7$.

Table 12. Efficacy of different botanicals for the management of insect pest of yard long bean yield during November, 2018 to march, 2019

Treatments	Yield plot^{-1} (kg)	Total yield(ton/ha)	% increase over control
T_1	10.27 b	14.68 c	26.55
T_2	10.98 a	15.68 b	35.17
T_3	9.63 c	13.77 d	18.71
T_4	8.96 d	12.77 e	10.09
T_5	9.99 bc	14.26 cd	22.93
T_6	11.60 a	16.57 a	42.84
T_7	8.11 e	11.60 f	---
LSD(0.05)	0.6237	0.8898	---
CV (%)	3.53	3.53	---

In a column, numeric value represents the mean of 3 replications; each replication is derived from 5 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1: Garlic bulb extract @ 5 ml per liter of water at an interval of 7 days ; **T_2:** Neem leaf extract @ 5 ml per liter of water at 7 days interval; **T_3:** Datura seeds extract @ 5 ml per liter of water at 7 days interval; **T_4:** Black pepper seed extract @ 5ml per liter of water at an interval of 7 days ; **T_5:** Mahogany seed extract @ 5 ml per liter of water at an interval of 7 days; **T_6**:Tobacco leaf extract @ 5 ml per liter of water at an interval of 7 days and**T_7:** Untreated control.]

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November, 2018 to march, 2019 to study the efficacy of different botanicals for the management of yard long bean against major insect pests. The seeds of BARI yard long bean-1 were used as the test crop in this experiment. The experiment comprised of the following botanicals as treatment-T_1 (Garlic bulb extract @ 5ml/L of water at 7days interval); T_2 (Neem leaf extract @ 5ml/L of water at 7 days interval); T_3 (Datura seeds extract @ 5ml/L of water at 7 days interval)**;** T_4 (Black pepper seed extract @ 5ml/L of water at 7 days interval); T_5 (Mahogany seed extract @ 5ml/L of water at 7 days interval); T_6 (Tobacco leaves extract @ 5ml/L of water at 7 days interval) and T_7 (untreated control) were included in this study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Data were recorded on different stages of yard long bean in term of number of insect per plant, number and weight of healthy pod, infested pod and percentage of pod infestation in number and weight, yield contributing characters and yield (t/ha) of yard long bean and observed statistically significant variation for different treatments.

Among seven treatments, it was observed that treatment T_6 (Tobacco leaves extract @ 5ml/L of water at 7 days interval) was the most effective treatment for reducing insect pests infestation at early, mid and late pod development stages.

Results revealed that in case of number of aphids per selected plantsat early, mid and late pod stage, the lowest presence (7.55, 3.77 and 8.83 respectively) was observed in T_6 (Tobacco leaf extract @ 5 ml/L of water) whereas the highest (21.88, 28.16 and 25.99 respectively) was in T_7(Untreated control). Similarly, the lowest number of jassid per plant at different cropping stages (3.55, 2.88 and 8.22 at early, mid and late pod stage respectively) was found inT_6 (Tobacco leaf extract @ 0.5 ml/L of water) whereas the highest (18.16, 22.50 and 23.38 respectively) was observed in T_7 (Untreated control). Again, the lowest number of pod borer per plant at different growing stages (0.89, 2.5 and 0.77 at early, mid and late pod stage respectively) was

found by T_6 (Tobacco leaf extract @ 5 ml/L of water) whereas the highest (11.44, 18.55 and 18.11 respectively) was observed in T_7 (Untreated control). Results also revealed that the lowest number of epilachna beetle per plant at different cropping stages (0.33, 0.77 and 0.22 at early, mid and late pod stage respectively) was found by T_6 (Tobacco leaf extract @ 0.5 ml/L of water) where the highest (8.88, 14.05 and 19.88 respectively) was observed in T_7 (Untreated control).

In relation to the % pod infestation, the lowest infested pods per selected plantsin number at early, mid and late stage (7.63%, 4.19% and 5.33% respectively) were recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) whereas the highest infested pods per plant in number (29.99 %, 17.44 % and 16.14 % respectively) were recorded from T_7 (Untreated control).

In relation to the pod infestation reduction over control by number, the highest reduction of infestation at early, mid and late stage (74.55%, 75.97% and 72.77% respectively) were recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) whereas the lowest at early, mid and late stage (18.34%, 37.04% and 21.75% respectively) were recorded from T_4 (Black paper seed extract @ 5 ml/L of water).

In relation to the % pod infestation by weight, the lowest infested pods perselected plants, at early, mid and late stage (3.00%, 7.63% and 9.40% respectively) were recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) whereas the highest (24.18%, 21.56% and 21.58% respectively) were recorded from T_7 (Untreated control). In relation to the pod infestation reduction over control by weight, the highest reduction of infestation at early, mid and late stage (87.59%, 64.61% and 56.44% respectively) were recorded from T_6 (Tobacco leaf extract @ 5 ml/L of water) whereas the lowest (29.36%, 28.94% and 25.12% respectively) were recorded from T_4 (Black paper seed extract @ 5 ml/L of water)

In total growing period by number of healthy pods, the maximum number of total healthy pods per selected plantswas recorded from T_6 (50.43) which was statistically different with T_2 (45.22) and T_1 (40.54) and followed by T_5 (36.2), while the least number of total healthy pods was observed from T_7 (28.6) followed by T_4 (32.76) and T_3 (35.26) treatments. On the other hand, the least number of total infested pods perselected plants was observed from T_6 (2.87) which was statistically different with T_2 (3.76) and closely followed by T_1 (4.48) and T_5 (4.98) treatments. In

contemporary, the maximum number of total infested pods was found from T_7 (6.93) followed by T_4 (5.37) and close to T_3 (5.15) treatment.

In context of healthy pods by weight, the maximum weight of total healthy pods per selected plantswas recorded from T_6 (687.5 g) which was statistically different with T_2 (631.93 g) and T_1 (574.66 g) and followed by T_5 (534.23 g), while the minimum weight of total healthy pods was observed from T_7 (400.66 g) followed by T_4 (475.61 g) and T_3 (509.93 g) treatments. On the other hand, the lowest weight of total infested pods per selected plantswas observed from T_6 (56.19 g) which was statistically different with T_2 (66.1 g) and closely followed by T_1 (74.48 g) and T_5 (83.02 g) treatments. In contemporary, the highest weight of total infested pods was found from T_7 (112.92 g) followed by T_4 (90.08 g) and close to T_3 (86.59 g) treatment.

The highest number of inflorescence per selected plantswas recorded from T_6 (48.33) which was statistically similar with T_2 (45.00), closely followed by T_1 (42.33) and close to T_5 (37.33) and followed by T_3 (35.00) while the lowest number was recorded from T_7 (27.33) and followed by T_4 (33.00) treatments. As a result, the order of rank of study the effect of different botanicals for the management of insect pest of yard long bean by number was $T_6 > T_2 > T_1 > T_5 > T_3 > T_4 > T_7$.

In the term of number of pods perselected plants, the highest number per selected plantswas recorded T_6 (73.22) which was statistically different with T_2 (65.49) and T_1 (62.90) and followed by T_5 (60.39), while the least number of total bean pods per selected plantswas observed from T_7 (49.16) followed by T_4 (58.61) and T_3 (59.66) treatments. As a result, the order of rank of study the effect of different botanicals for the management of insect pest of yard long bean by number was $T_6 > T_2 > T_1 > T_5 > T_3 > T_4 > T_7$.

In the term of pod length, the longest pod length was recorded from T_6 (46.94 cm) which was statistically identical with T_2 (44.92 cm), closely followed by T_1 (42.81 cm) and close to T_5 (42.18 cm) while the minimum number was recorded from T_7 (35.93 cm) and followed by T_4 (40.33 cm) and T_3 (40.61 cm) treatments. As a result, the order of rank of study the efficacy of different botanicals for the management of insect pest of yard long beanby number was $T_6 > T_2 > T_1 > T_5 > T_3 > T_4 > T_7$.

The highest yield per plot was observed from T_6 (11.60 kg) which was statistically similar with T_2 (10.98 kg), closely followed by T_1 (10.27 kg) and close to T_5 (9.99 kg)

and followed by T_3 (9.63 kg) while the lowest yield per plotwas recorded from T_7 (8.11 kg) and identically followed by T_4 (8.95 kg) treatments. The highest yield per hectare (16.57 ton) was obtained in T_6 treatment and the lowest yield per hectare (11.60 ton) was recorded in T_7 treatment.

CONCLUSION

From the above representation, it can be concluded that, spraying Tobacco leaf extract @ 5ml/L of water at 7 days interval was considered the best followed by Neem leaf extract @ 5ml/L of water at 7 days interval for the eco-friendly management of yard long bean against the major insect pests.

RECOMMENDATIONS

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

- This experiment may be conducted in different locations of Bangladesh for accuracy of the results obtained from the present experiment.
- Diversity of insect pests studied all over Bangladesh to identify the major insect pests of yard long bean.
- Further trials with effective different botanicals may be done at different locations of Bangladesh to find out their efficacy to manage insect pest.

CHAPTER VI

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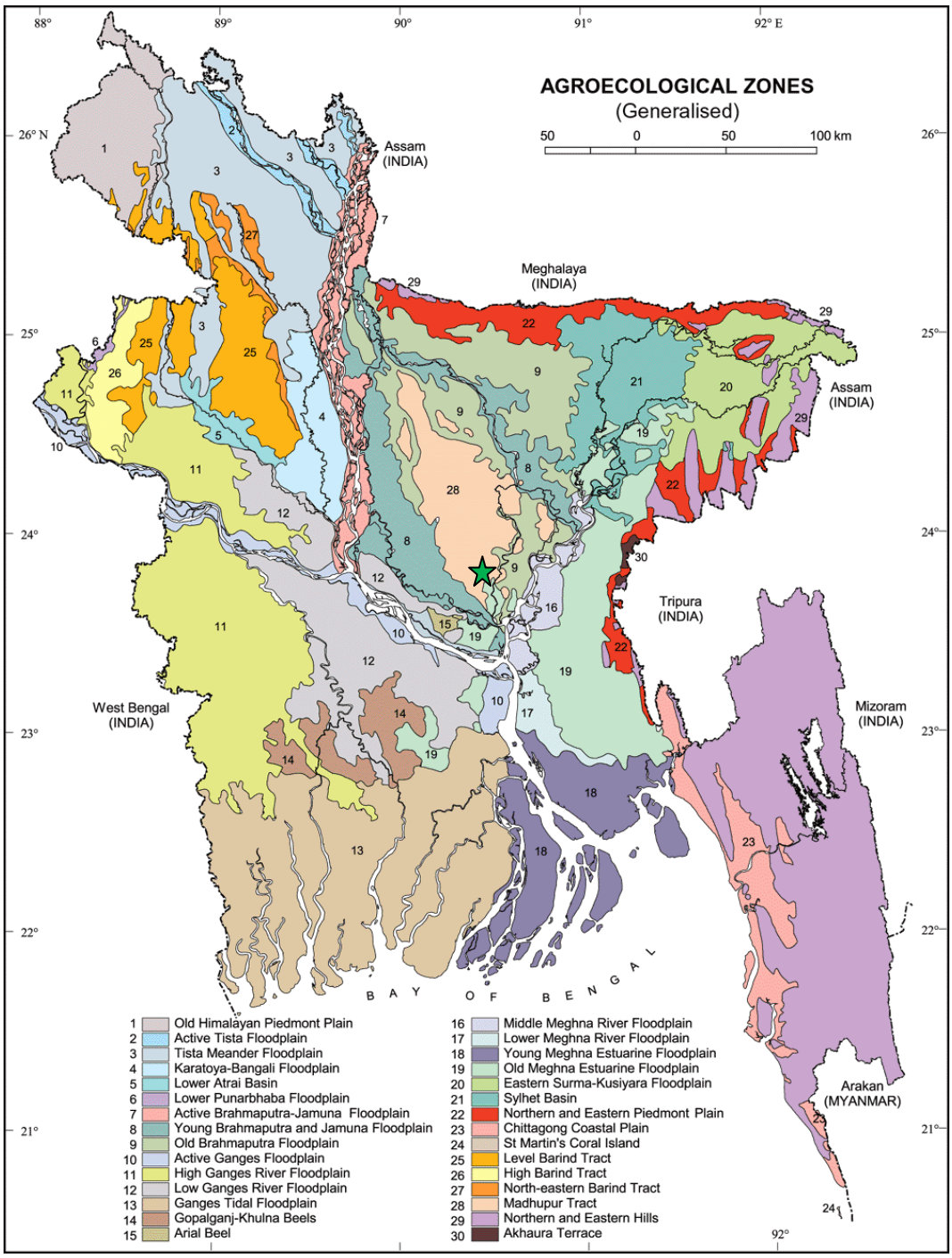
APPENDAGES

Appendix I. Map showing the experimental site under the study



The experimental site under the study

Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	Characteristics
Location	Central Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

A. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

B. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix III. Monthly air temperature, relative humidity, total rainfall and Sunshine of the experimental site during November, 2018 – April, 2019

Year	Month	*Air temperature (ºC)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
		Maximum	Minimum			
2018	November	19.2	29.6	53	34.4	11
2018	December	14.1	26.4	50	12.8	11
2019	January	12.7	25.4	46	7.7	11
2019	February	15.5	28.1	37	28.9	11
2019	March	28.1	19.5	68	00	6.8
2019	April	33.4	23.2	67	78	6.9

* Monthly average,

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

Appendix IV. Analysis of variance of data on number of insects per selected plants of yard long bean at early pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of			
		Aphid (No./plant)	Jassid No./plant)	Pod borer (No./plant)	Epilachna beetle (No./plant)
Replication	2	0.051	0.176	0.218	0.364
Treatment	6	63.586**	69.705**	33.999**	22.124**
Error	12	0.443	0.209	0.156	0.093

**significant at 1% level of probability

Appendix V. Analysis of variance of data on number of insectsper selected plants of yard long bean at mid pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of			
		Aphid (No./plant)	Jassid No./plant)	Pod borer (No./plant)	Epilachna beetle (No./plant)
Replication	2	0.142	0.984	0.0569	0.197
Treatment	6	206.123**	130.711**	80.273**	57.837**
Error	12	0.230	0.124	0.268	0.122

**significant at 1% level of probability

Appendix VI. Analysis of variance of data on number of insects per selected plants of yard long bean at late pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of			
		Aphid (No./plant)	Jassid No./plant)	Pod borer (No./plant)	Epilachna beetle (No./plant)
Replication	2	0.196	0.279	0.166	0.477
Treatment	6	77.510**	75.839**	97.094**	124.317**
Error	12	0.434	0.354	0.244	0.213

**significant at 1% level of probability

Appendix VII. Analysis of variance of data on number of podper selected plants of yard long bean at early pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of	
		Healthy	Infested
Replication	2	0.137	0.021
Treatment	6	16.133**	0.461**
Error	12	0.245	0.013

**significant at 1% level of probability

Appendix VIII. Analysis of variance of data on number of pod per selected plants of yard long bean at mid pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of	
		Healthy	Infested
Replication	2	0.066	0.013
Treatment	6	19.731**	0.929**
Error	12	0.445	0.021

**significant at 1% level of probability

Appendix IX. Analysis of variance of data on number of pod per selected plants of yard long bean at late pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of	
		Healthy	Infested
Replication	2	0.049	0.005
Treatment	6	21.701**	0.359**
Error	12	0.323	0.016

**significant at 1% level of probability

Appendix X. Analysis of variance of data on weight of pod per selected plants of yard long bean at early pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of	
		Healthy	Infested
Replication	2	88.510	0.313
Treatment	6	2101.08**	60.312**
Error	12	26.57	0.380

**significant at 1% level of probability

Appendix XI. Analysis of variance of data on weight of pod per selected plants of yard long bean at mid pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of	
		Healthy	Infested
Replication	2	124.06	0.176
Treatment	6	4910.31**	184.922**
Error	12	94.59	2.451

**significant at 1% level of probability

Appendix XII. Analysis of variance of data on number of pod per selected plants of yard long bean at late pod development stage

Sources of Variation	Degrees of freedom	Mean Square value of	
		Healthy	Infested
Replication	2	56.21	1.228
Treatment	6	2462.34**	110.388**
Error	12	64.52	3.053

**significant at 1% level of probability

Appendix XIII. Analysis of variance of data on yield contributing characteristics of yard long bean at total growing period

Sources of Variation	Degrees of freedom	Mean Square value of		
		Number of inflorescence plant^{-1}	Number of pod plant^{-1}	Pod length (cm)
Replication	2	9.476	25.410	11.009
Treatment	6	161.000**	160.154**	37.591**
Error	12	7.810	12.373	7.136

**significant at 1% level of probability

Appendix XIV. Analysis of variance of data on yield plot^{-1}and yield(ton/ha) of yard long bean at total growing period

Sources of Variation	Degrees of freedom	Mean Square value of	
		Yield plot^{-1} (kg)	Total yield(ton/ha)
Replication	2	0.157	0.326
Treatment	6	4.192**	8.529**
Error	12	0.123	0.250

**significant at 1% level of probability