A SEMINAR PAPER ON

Biorational Approaches on Brinjal Insect Pests Management and Their Impact on Natural Enemies

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ABSTRACT

Chemical insecticides are so much destructive and highly toxic to living organisms and to the environment; consequently, biorational approaches to pest control have been introduced to control insect pests. In this paper, there is presented an upgrade of those approaches. The studies on to control insect pest by different biorational approaches rather than conventional insecticide and to give emphasize on biorational approaches. Because, biorational insecticides have the low toxic effect or no toxic effect to plant. During the past century, significant progress has been done in the synthesis of new insecticides. Agricultural production is minimized by the Compounds such as chlorinated hydrocarbons, organophosphates, and carbamates. They have been introduced and used to control insect pests. Unfortunately, most of these chemicals are destructive to man and to beneficial organisms. Therefore, the rapidly developing resistance to conventional insecticides provides the impetus to study new alternatives and more ecologically acceptable insecticides. The natural products (emamectin, milbemectin, abamectin, and spinosad) that act on glutamate receptors, GABA receptors and chloride channels with much more affinity for insect sites than for mammal sites have been introduced and used successfully to minimize a diversity of insect pests. A diversity of new botanical insecticides with special activity on insect pests is in the process of development and their importance are very much high in controlling insect pests.

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CHAPTER 1

INTRODUCTION

In many tropical and subtropical parts of the world, Brinjal (*Solanum melongena* L.) is a plant of considerable economic importance in many aspect. It is one of the broadely used vegetable crop by most of the people and is popular in many countries *viz.*,some parts of Africa,Central America and South East Asia (Channe *et al.,* 2013). It is grown throughout the country and native of India (Choudhary, 1970). Eggplant was originated from India and Indochina (Vavilov, 1951). Brinjal occupies an area of 18.53 lakh ha and covered with a production of 484.24 lakh tons in the world (FAO, 2012). 90 per cent of output coming from five countries. First position is occupied by China (58 per cent of world output) followed by India (25 per cent).Brinjal occupies an area of 7 lakh ha with a production of 122 lakh tons in India (FAO,2012).Throughout the year in almost all parts of the country except in higher altitudes and liked by both poor and rich alike have grown brinjal. Among the few vegetables, brinjal is capable of high yields in hot-wet environments and is well adapted to grow in high temperatures and high rainfall (Hanson et al. 2006). Because of its nutritive value,it is grown in all the seasons and consisting of minerals like vitamins like A, B and C, calcium,iron, and phosphorous. Unripe fruits are considered primarily as vegetable in the country. Brinjal is also used as a raw material in pickle making (Channe *et al.,* 2013) has an excellent remedy for suffering from liver complaints, Ayurvedic medicine for curing the diabetes and also used as a good appetizer.

Brinjal is attacked by number of insect pests right from seedling stage to harvesting. In the tropics, brinjal production is severely dicreased by several insect and mite pests. The major insect pests like brinjal shoot and fruit borer(BSFB), leaf roller, stem borer, blister beetle, leafhopper, whitefly, thrips, aphid, spotted beetles, red spider mite are more destructive. Growers depend on heavily on chemical pesticides to manage their eggplant crop. Among the insect pests, the most voracious and destructive ones are the shoot and fruit borer and epilachna beetle. Minor pests like leaf roller and hairy caterpillar are considered the main constraint as it damages the crop throughout the year. 70-92% yield is lost by due to the major pests (Reddy and Srinivasa, 2004; Chakraborti and Kanti, 2011; Jagginavar *et al.,* 2009). Among them, shoot and fruit borer is the most important and destructive pest. Shoots and fruits are bored by the larvae and feed on the internal tissues (Srinivasan, 2008). Withering of terminal shoots, bore holes can be seen on fruits plugged with excreta due to infestation and the shedding of flower buds and drying of leaves also seen due to boring of petioles.

Most of the farmers depend on synthetic chemical insecticides for the management of these pest. Though the present recommendation of insecticidal application controls the insect pests, but they are undesirable due to their high costs , high toxicity, possible development of resistance among pest species and environmental unfriendliness, resurgence of certain pest populations and adverse effect on beneficial organisms such as pollinators and natural enemies. Malathion 50 EC is more toxic to human being than the insecticide spinosad 45 SC and approved for utilize in organic agriculture by numerous and national certification (Thomas *et al.*, 2012). Therefore low-cost bio-rational based pest management (IPM) techniques render satisfactory, sustainable management and can assist eggplant growers decrease their assurance on chemical pesticides and also can shelter the natural enemy. Pesticide misemployment has disastrous effects on the environment and human health and also increases the cost of production. The contribution of the cost of pesticide to total material input cost was 55% for eggplant compared with cabbage (49%) and tomato (31%) in the Philippines (Orden et al. 1994), and recorded for 40–50 percent in Bangladesh (SUSVEG-Asia 2007). It is necessary to apply such bio-rational approaches for brinjal insect pests, which match into IPM strategy and will be much safe, economical as well as selective.

Keeping these considerations in view, the present study has aimed with the following objectives

- ❖ To evaluate the efficiency of microbial preparations, biorational and neem based insecticides against major pests of brinjal
- ❖ To highlight the most effective bio-rational approaches for the management of brinjal insect pests.
- ❖ To assess the impact of those bio-rational approaches on natural enemy in the brinjal field.

CHAPTER 2

MATERIALS AND METHOD

This seminar paper is completely a review paper. Therefore, all the information were collected from secondary sources with a view to prepare this paper. The key information were collected from various relevant books and journals, which were available in the library of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) and Bangladesh Agricultural Research Institute (BARI). For collecting recent information internet browsing was also done. Good suggestions, valuable information and kind consideration from my honorable major professor, research supervisor, course instructors and other resources personnel were taken to enrich this paper. After collecting necessary information, it has compiled and arranged chronologically for better understanding and clarification.

CHAPTER 3

REVIEW OF FINDINGS

Biorational Pesticides

"Biorational" has been introduced recently to descent those insecticides that are efficacious against the target pest but are less destructive to natural enemies. The term at times has been utilized to desalinate only those products that evolved from natural sources, i.e. plant extracts, insect pathogens, etc. A biorational pesticide may be referred as "any type of insecticide that is active against pest populations, but relatively innocuous to non target organisms and therefore, non-destructive to biological control." An insecticide can be "innocuous" by having low or no direct toxicity, or by consisting systemic or rapid translaminar activity or short field residual, thereby minimizing expression of natural enemies to the insecticide.

Types of Bio-rational Pesticides

Plant Materials

- Botanicals and Florals
- Natural toxicants like nicotine
- Alkaloids (some are toxic to all animals)
- Neem (Azadirachtin less toxic but still useful in greenhouses).

Insect Growth Regulators (IGR)

- Juvenile Hormones
- Precocenes
- Chitin Synthesis Inhibitors

Bacterial Fermentation Products

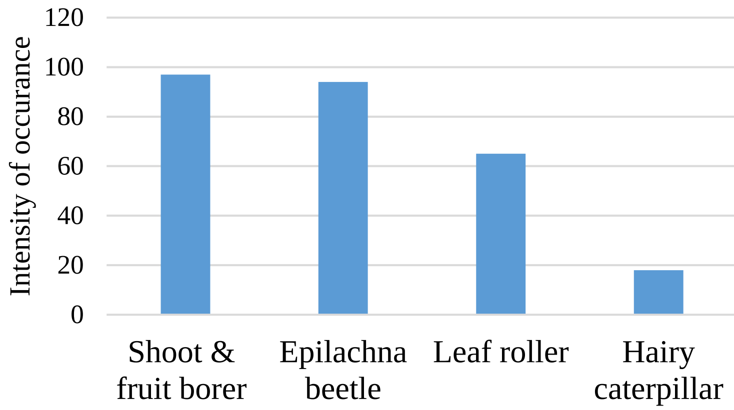
- Acetylcholine (Ach) receptors - Spinosad (has certified organic formulations)
- Gamma Amino Butyric Acid (GABA) inhibitors – Avermectin

Microbials

Bacteria (Bt varieties mostly), Fungi (Metarhizium anisopliae newest labels), Viruses,Nematodes Genetically modified plants (Produce Bt toxins).

Incidence of pests in brinjal field

Fig 1 indicated that among the major insect pests of brinjal, most devastating infestation occurred by the brinjal shoot & fruit borer in brinjal field followed by epilachna beetle & leaf roller.Lower infestation is occurred by hairy caterpillar.



(Source: Gowrish *et al.*,2014)

Figure 1: Intensity of occurance of different brinjal pests

Borer insect pest of brinjal

Brinjal shoot and fruit borer (BSFB)

***Leucinodes orbonalis* Guenee**(Lepidoptera: Pyralidae)

Brinjal shoot and fruit borer(BSFB) is one of the most deleterious pests on eggplant in South and Southeast Asia. It is placed throughout the tropics in Asia and Africa, where it can abate yield by as much as 70%. During *kharif*, 2010 and 2011; the percent avoidable losses were 48.87 and 47.63, respectively, average damage of 13.30 percent due to shoot and fruit borer alone. Muthukumar and Kalyanasundaram (2003) reported that the higher shoot damage ranged between 30.23 and 36.23 percent, while fruit damage ranged from 37.51-42.23 percent. Varma *et al.*, (2009) reported that the damaged fruits and fruit weight loss varied from 3.76 to 45.45 per cent and 3.00 to 67.71 per cent in first year and 5.71 to 44.26 per cent and 3.00 to 51.33 per cent in second year due to *L. orbonalis*.

Figure 2. Dried shoot and damaged fruit caused by BSFB. (Source: Srinivasan, 2009)

Management by parasitoids

Any single method of pest management alone will not achieve a level of BSFB control acceptable to producers. A simple and economic technique can provide satisfactory control.

- Biological method recommended by IIHR, Bengaluru involving release of *Trichogramma chilonis* @10 to 15 lakh parasites/ha/season along with 2 sprays of *Bt* formulation found to be economically effective.
- Protection of parasitoids such as *Trathala flavoorbitalis*(Cameron), *Eriborussinicus* Holmgren, and *Pristomerus testaceus* Morley. Reduced use of synthetic pesticides will enhance the activities of these natural enemies. In addition, weekly releases of egg parasitoid, *Trichogramma chilonis* Ishii @ 1gparasitized eggs/ha/week and larval parasitoid, *Bracon habetor* Say @ 800-1000 adults/ha/week could be followed (Alam *et al*., 2006).
- Installation of BSFB sex pheromone lures in traps at the rate of 100 traps per hectare. Placement of the traps either at canopy level or at slightly above the canopy level for effective attraction the damaged eggplant fruit.

Figure 3: Installation of BSFB sex pheromone trap in brinjal field.
(Source: Islam, 2012)

The result indicated encouraging performance of bio-rational to reduce brinjal shoot and fruit borer population on brinjal (Table 1). The lowest shoot and fruit infestation was obtained from the parasitoid applied plot (23.75 & 20.45%) whereas the highest in chemical applied plot (36.72 and 29.65%). The infestation status of bio-rational pesticide and non treated plots reflects in the yield. Comparative higher yield was obtained from treated plots **(**20.24 t/ha**)** than non treated(14.76t/ha**)** which was 37.12% higher compared to non treated.

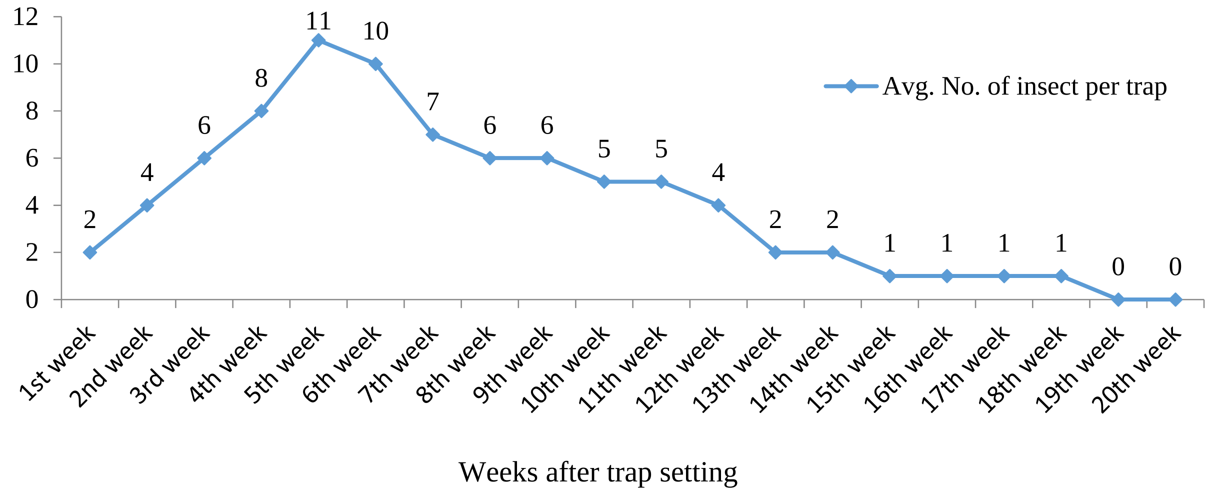
Table 1.Effect of parasitoids against Brinjal shoot and fruit borer in brinjal at Dadra, Joypurhat during 2013

** = Significant at 1% level

<table>
<tr><th>Treatments</th><th>Shoot infestation (%)</th><th>Reduction of shoot infestation (%)</th><th>Fruit infestation (%)</th><th>Reduction of fruit infestation (%)</th><th>Yield (t/ha)</th><th>Yield increase (%)</th><th>Insect captured/ trap/week</th></tr>
<tr><td>Sex pheromone trap+Trichogramma evanescens@1g/ha+ Braconhebetor @ 1 bunker (1000-1200 adults)/ha</td><td>23.75</td><td>35.32</td><td>20.45</td><td>31.03</td><td>20.24</td><td>37.12</td><td rowspan="4">3.12</td></tr>
<tr><td>Spray with sevin 85 SP powder, malathion, ripcord</td><td>36.72</td><td>-</td><td>29.65</td><td>-</td><td>14.76</td><td>-</td></tr>
<tr><td>“t” value</td><td>22.80</td><td>-</td><td>17.56</td><td>-</td><td>13.23</td><td>-</td></tr>
<tr><td>Level of significance</td><td>**</td><td>-</td><td>**</td><td>-</td><td>**</td><td>-</td></tr>
</table>

(Source: Anonymous, 2014)

No. of captured insect/trap was.3.12 in sex pheromone trap. Number of captured adult per trap increased with the increase of plant age and reached peak at 4th – 7th week of trap setting and thereafter population decreased with the progress of the season(Fig. 4).



(Source: Anonymous, 2014)

Figure 4.Average number of insect per trap in different weeks after trap setting.

Evaluation of botanical tablets against shoot and fruit borer on brinjal

Tablets at dose 1:4 (w/v) were sprayed before releasing brinjal shoot and fruit borer in plot with eggplant at flowering and fruiting stage. Flowering stage: In this stage, the lowest shoot infestation and fruit infestation were recorded in Neem. In case of shoot infestation, Garlic and Garlic+Neem treatments showed statistically similar effect but lower than the untreated condition. Highest percentage of shoot infestation and fruit infestation were obtained in untreated eggplants, which were significantly higher than the Neem treatment . Fruiting stage: In case of shoot infestation, Garlic and Garlic+Neem treatments showed statistically similar effect but lower than the untreated condition. Neem treatment was very effective to reduce shoot and fruit infestation than the other treatments. Lowest percentage of shoot infestation and fruit infestation were recorded in eggplant treated with Neem. All other treatments showed statistically similar effect on fruit infestation. Highest percentage of shoot infestation and fruit infestation were obtained in untreated eggplants which were significantly higher than the Neem treatment. (Table 2).

Table 2.Effect of some botanical tablets on infestation of shoot and fruit borer of eggplant at fruiting stage

Treatment	Shoot infestation (%)	Fruit infestation (%)
Garlic	21.00 b	38.33 b
Allamanda	23.33 ab	40.00 b
Neem	13.33 c	24.68 c
Garlic+Neem	20.00 b	35.68 b
Allamanda+Neem	22.50 ab	36.00 b
Control	28.33 a	56.68 a
LSD (P=0.01)	6.12	6.64

Significant at 1% level (Source: Moniruzzaman *et al.*, 2010)

Effects of spinosad and sex pheromone trap alone and in combination against the brinjal fruit infestation by *L. orbonalis*

The percent of injured fruits ranged from 5.95% to 46.35%. The highest fruit infestation (46.35%) was seen in control plot and the lowest was seen from spinosad + pheromone trap. Like as stem infestation, the fruit infestation was also significantly waned when eggplants were applied with spinosad (14.09%) or pheromone trap (19.18%) alone in compared with that in the water-treated control (46.35%) .It was found that the spinosad mixed better than pheromone trap considering fruit damage although the difference was insignificant. It was amazing that the accomplised management practices of setting pheromone trap with spinosad spraying waned the eggplant fruit infestation (5.95%) significantly ($p<0.01$) than other treatments (14.09% for spinosad and 19.18% for pheromone trap). It has been recorded that data were collected on fruit damage at 7 days (data not shown) and 15 days after spinosad spraying. The data presented in table 3 expressed that the treatment spinosad + pheromone provided maximum fruit protection (about 87.16%) against control while pheromone and spinosad individually provided 58.61 and 69.60% fruit protection against control respectively. Therefore, it is clear that, maximum number of brinjal fruits can be protested from BFSB infestation through combined use of spinosad and pheromone than their individual application (Mamun *et al.*,2014).

Table 3:Effects of spinosad, pheromone trap and spinosad + pheromone trap on fruit damage by *L. orbonalis*

Treatments	Number of infested fruits(Before treatment)	Number of infested Fruits (After treatment)	% of fruit damage	% protection over control
Spinosad (Libsen 45 SC)	10.22	1.44	14.09b	69.60
Pheromone trap	5.63	1.08	19.18b	58.61
Spinosad + Pheromone trap	5.54	0.33	5.95c	87.16
Control	3.67	1.67	46.35a	----

(Source: Mamun *et al*.,2014)

Bacillus thuringiensis

The best-known *Bacillus* species utilized as a biopesticide is *B. thuringiensis*(Bt). This bacterium generate the proteins Cry and Cyt which are highly toxic to insects but not to mammals or for the environment. This contributes to reveal the early use of this biopesticide which was first applied in 1938. Cry toxins are integral part of the structure of the *B.thuringiensis'* spores. When these bacterial spores are inserted by an insect, the Cry proteins act through pore formation in the gut wall of the animal allowing the bacteria that come out from the spores to feed on the contents of the insect's body cavity. This generates a new bacterial population and thus a new source of spores after the death of the insect. To combat the infestation of Brinjal shoot and fruit borer,scientist gave efforts to develop the natural resistance or tolerance against the pest.They insert Cry1 Ac gene from soil bacterium, *Bacillus thuringiensis* into brinjal. Hence,two local brinjal cultivars namely,ISD006 and Uttara were transformed under ABSP-II program (BARI, 2014).

Leaf roller

Damage symptoms

Young leaves are rolled lengthwise. Rolled leaves are brown and eventually dry. In heavy infestations entire portions of plants appear brown and leaf drop occurs.

Insect characteristics

Caterpillars are purple-brown with many cream colored hollow bumps and long hairs on the back and sides. The adult is an olive green moth that is active at night.

Where to look

Inspect the young leaves for signs of silken webbing and rolled/leaves. Open these leaves and look for the caterpillar and signs of chewing damage on the leaf surface.

Life cycle

The female adult lays eggs in masses on the young leaves. Each egg mass may have 8–22 eggs. The caterpillar feeds for about four weeks and then pupates inside the rolled leaf. In favorable climates there may be three to four generations each year.

Scientific name: *Eublemma olivacea*

Figure 5:Infested leaves by leaf roller

(Source: Srinivasan, 2009)

Sucking insect pests of brinjal

Sucking pests such as aphids, jassids, white fly, thrips and mites etc. are gaining tremendous importance in the recent years due to their devastating damage. Aphid (*Aphis gossypii* Glover), Jassid (*Amrasca biguttula biguttula* Ishida) and white fly (*Bemisia tabaci* Gennadius) suck the cell sap and preventing normal crop growth (Alam *et al.*, 2004). Beside direct damage, the sucking pests acts as vector for virus borne diseases (Munde *et al.*, 2011).

Leaf hopper

***Amrasca devastans* Distant**(Hemiptera: Cicadellidae)

The preferred scientific name for this leafhopper is *Amrasca biguttula biguttula* Ishida (CABI 2007). Both nymphs and adults suck the sap from the lower leaf surfaces through their piercing and sucking mouthparts. When several insects suck the sap from the same leaf, yellow spots appear on the leaves, followed by crinkling, curling, bronzing, and drying, or "hopper burn".(Srinivasan,2009)

Figure 6. Leafhopper- nymphs feeding on brinjal leaf and hopper-burn symptom on leaf. (Source: Srinivasan, 2009)

Management

- Generalist predators such as ladybird beetles and green lacewings are highly competent in preying on leafhopper nymphs and adults. Parasitoids such as *Anagrus flaveolus* Waterhouse and *Stethynium triclavatum* Enock are efficacious against leafhopper (Subba Rao, 1968; Parker *et al.*, 1995).
- Neem-based biopesticides at recommended doses should be used. Instead of commercial neem formulations, neem seed kernel extract (NSKE) @ 5%can be sprayed.

Whitefly

Bemisia tabaci (Hemiptera: Aleyrodidae)

The whitefly is most widely distributed in tropical and subtropical parts, and in greenhouses in temperate regions. Nymphs and adults have sucking types mouthparts and reduce the vigor of the plant. In severe infestations, the leaves becomes yellow and drop off. In case of higher populations, they secrete large quantities of honeydew, which favors the growth of sooty mould on leaves and reduces the photosynthetic activity of the plants.(Srinivasan, 2009)

Figure 7: Sooty mould on whitefly infested leaves.

(Source: Srinivasan, 2009)

Thrips

***Thrips palmi* Karny**(Thysanoptera: Thripidae)

Thrips are most widely distributed in South Asia, South east Asia, and Oceania. Though it prefers to feed on cucurbits, occasionally it infests eggplant most severely.

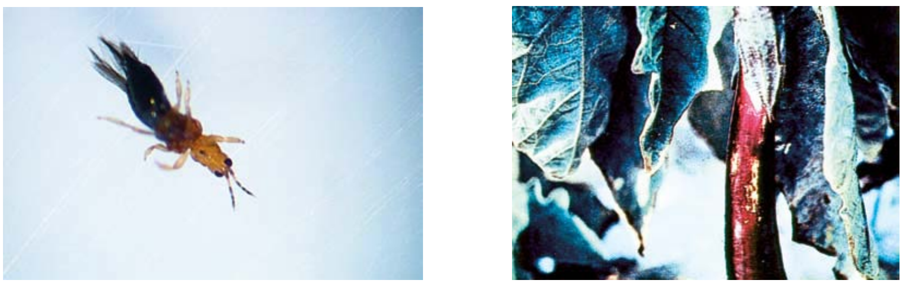


Figure 8: Adult of Thrips and its feeding damage on the fruits.

(Source: Srinivasan, 2009)

Aphid

Aphis gossypii (Hemiptera: Aphididae)

This is a universal pest and highly polyphagous. It feeds on cotton, cucurbits, eggplant, and okra.

Management

▪ The ladybird beetles (*Menochilu* sp. And *Coccinella* sp.) and green lacewings are efficacious predators of aphids. Inundative release of ladybird beetles @ 200 pairs per ha at fortnightly intervals can inhibit the aphid population.

Figure 9: Green lacewing larva attacking aphid with its mandibles.

(Source: Dreistadt, 2014)

Red spider mite

Tetranychus urticae (Acarina: Tetranychidae):Red spider mite appeared as a highly destructive pest of vegetable crops including brinjal, tomato, and other field crops in South Asia, South east Asia. Spider mites usually extract the cell sap from the leaves using their long, needle- like mouthparts. They reduce chlorophyll content in the leaves. The mites found to the tip of the leaf or top of the plant and forms a ball-like mass which will be blasted by winds to new leaves or plants, in a process known as ballooning.

Figure 10: White and yellow speckles caused by spider mites and congregation of spider mites in the leaf tip.

(Source: Srinivasan, 2009)

Management

Predatory mites can be used to control spider mites. They are more efficient under protective structures and in high humidity conditions.

- Green lacewings (*Chrysoperla carnea*) also are efficacious.

. A third instar grub of *C. carnea* could consume 25–30 spider mite adults per day; however, it needs supplemental food for long-term survival (Hazarika *et al.*, 2001).

Natural enemies

In nature, insects are annoyed by numerous living organisms that feed upon them. These are called natural enemies or beneficials and are of great value to eggplant growers. Natural enemies include predators such as mantids, lady beetles , earwig, green lacewing, and spiders. These natural enemies can be seen during the day feasting on a wide variety of pests and other insects in the field. In general, there are tiny wasps called parasitoids, the larvae of its feed on the pest insect and kill it from within. Chemical pesticides used in killing pest insects will also kill most beneficial insects. Sometimes natural enemy populations build up slowly and a resurgence of the pest after a pesticide application can occur. In general, when the natural balance between the beneficial and pest complexes is hampered, a different, previously minor, pest species can unexpectedly cause major damage. Therefore, utmost care should be taken to use a pesticide that targets the pest insect and does not harm the natural enemies, if possible. Bacteria, fungi, nematodes, viruses, and protozoans also kill insect pests. Each of these is an important component of the natural biological control system. Such as

- Ladybird beetle larva and adult
- Mantid
- Predatory bug
- Earwig
- Spider

Effect of botanical extracts against sucking pest attack on brinjal leaves

In table 4, effect of eight botanical extracts was tested in experimental brinjal field. Out of them Khuksha leaves extract (3.71) showed best performance against the pest attack on brinjal leaves compare to control (8.13). Marigold leaf extracts was also found very efficacious (4.63). The efficiency of Chotra (4.71) and Chirata (4.55) leaf extracts was nearly same in brinjal plot against the pest attack .

Table 4. Impact of botanical extracts opposed to sucking pest attack on brinjal leaves

Sl. No	Treatments	No. of infested leaves
1.	Mahogany seed	6.06abc
2.	Khuksha leaves	3.71d
3.	Chotra leaves	4.71bcd
4.	Chirata leaves	4.55bcd
5.	Neem leaves	6.21ab
6.	Bael	4.14bcd
7.	Holde-hurhuri	6.34ab
8.	Marigold leaves	4.63cd
9.	Control	8.13a

Means followed by same letters do not differ significantly by DMRT ($P < 0.05$)

(Source: Azad *et al.*,2012)

Table 5 indicated that mean aphid population was lowest (2.04/five leaves) in white & yellow sticky traps + Actara 25WG and it was followed by white & yellow sticky traps + Fytoclean. The control treatment exhibited significantly highest (18.06/five leaves) aphid population. Similarly, the mean jassid population was significantly lowest (4.21/five leaves) in Actara +white & yellow sticky traps and it was followed by Bio neem plus +white & yellow sticky traps (6.01/five leaves). The control treatment recorded significantly highest jassid population (19.22/five leaves). The mean thrips population was lowest (6.02/five leaves) in Bioneem plus 1 EC + white & yellow sticky traps. The control treatment recorded significantly highest number of (14.53/five leaves) thrips population. The mean whitefly population was lowest (4.03/five leaves) in Bioneem plus 1 EC + white & yellow sticky traps. The control treatment recorded significantly highest number of (10.87/five leaves) whitefly population. In terms of the percent insect pest population reduction over control , the highest reduction of Aphid and Jassid population over control was obtained from Actara+white & yellow sticky traps(88.70% & 78.10%) for aphid and jassid, respectively) , while Bioneemplus +white & yellow sticky traps offered the highest reduction of thrips (58.57%) and white fly (62.93%) population over control.

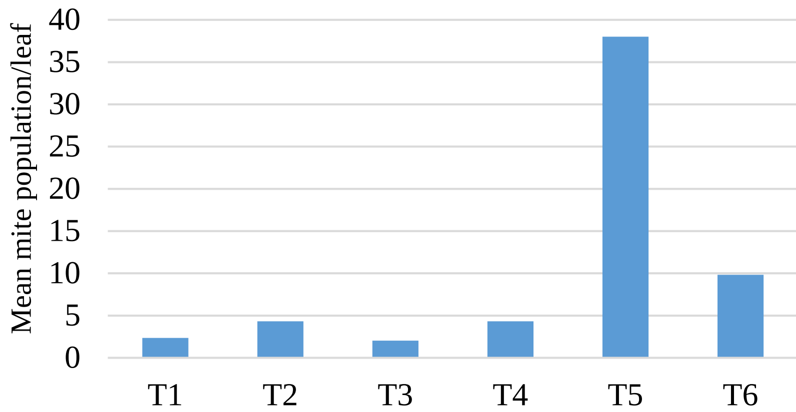
Table 5.Mean population of aphid, jassid, thrips and whitefly in brinjal as influenced by different treatments

Treatments	Mean Aphid population /5 leaves	Mean Jassid population /5 leaves	Mean Thrips population /5 leaves	Mean Whitefly population /5 leaves
Bioneemplus +white & yellow sticky traps	4.21bc	6.01bc	6.02c	4.03c
Bioneem+white & yellowsticky traps	8.21b	8.21b	9.21b	6.85b
Fytomax+white & yellowsticky traps	4.42bc	5.98bc	6.25c	4.75c
Fytocean+white & yellowsticky traps	3.98bc	6.21bc	6.91c	4.85c
Actara+white & yellowsticky traps	2.04c	4.21c	6.82 c	4.17c
Untreated control	18.06a	19.22a	14.53a	10.87a
CV %	4.98	6.51	8.12	10.39

Means having same letter(s) in a column are not significantly different at P> 0.01 followed by LSD.

(Source: Anonymous, 2014)

The fig 11 indicated the highest mite population was recorded in white & yellow sticky traps + Actara 25WG treated plots (38.02 mites/leaf) while mite population was the lowest in white & yellow sticky traps + Fytomax 3EC treated plots (2.03 mites/leaf). Serious outbreak of this pest could be attributed to the spraying of Actara 25WG, which is a synthetic chemical insecticide. Dobson *et. al*. (2002) reported that the outbreak of this pest is assumed to be the consequences of frequent and indiscriminate use of toxic chemicals especially pyrethroid insecticides by farmers.



(Source: Anonymous, 2014)

Figure 11. Mean mite population/leaf in brinjal as influenced by different treatments

Bioneem plus 1 EC + white & yellow sticky traps, T_2= Bioneem 0.3 EC + white & yellow sticky traps, T_3= Fytomax 3 EC + white & yellow sticky traps, T_4= Fytocean+ white & yellow sticky traps, T_5=Actara 25WG + white & yellow sticky traps, T_6= Untreated control

Benefit/ cost analysis: The benefit-cost ratios (BCR) of different treatments applied against sucking pests of brinjal as worked out based on the expenses incurred and value of crops is presented in Table 6. It was to be noted here that expenses incurred referred to those only on pest control. It is revealed that the highest benefit-cost ratio (3.06) was calculated from Bioneem plus + white & yellow sticky traps treated plots followed by Fytomax 3 EC + white & yellow sticky traps (2.62) sprayed plot. In contrast the lowest BCR (0.69) was obtained from Actara 25WG + white & yellow sticky traps treated plots. So, considering BCR, Bioneem plus along with installation white & yellow sticky traps may be recommended for effective management of sucking pests in brinjal field.

Table 6. Benefit cost analysis after application of different management options for controlling sucking pests of brinjal

Treatments	Marketable yield (t/ha)	Gross return (Tk/ha)	Cost of Treatment (Tk/ha)	Net return (Tk/ha)	Adjusted Net return (Tk/ha)	Benefit/ Cost Ratio (BCR)
Bioneemplus +white & yellow sticky traps	18.32	274800	15760	259040	48290	3.06
Bioneem+white & yellow sticky traps	15.87	238050	15760	222290	11540	0.73
Fytomax+white & yellow sticky traps	17.85	267750	15760	251990	41240	2.62
Fytocean+white & yellow sticky traps	17.97	269550	17760	251790	41040	2.31
Actara+white & yellow sticky traps	15.51	232650	12960	219690	8940	0.69
Untreated control	14.05	210750	0	210750	0	-

(Source: Anonymous, 2014)

Leaf eating insect pest of brinjal

Epilachna beetles

E. vigintiocto punctata (Coleoptera: Coccinellidae)

Epilachna beetles are widely distributed from East Asia to South Asia and Australia. They are polyphagous. These beetles are concerned to be one of the most destructive groups of pests damaging eggplant. (David, 2001).

Figure 12: Ladder-like windows caused by Epilachna beetle feeding
(Source: Srinivasan, 2009)

Management by different plant extracts

A comparative study was carried out on insecticidal activity of neem leaves extract opposed to first instars of *E. vigintiocto punctata* by Saxena and Sharma (2005). But Satpathi and Ghatak (1990) have recorded 90% mortality of the same beetle with same concentration of root extract of *T. nerifolia* which was very similar to the present findings and affirm the insecticidal activity of the plant. The authors recorded that the extract was larvi-cidal causes mortality with 1.0% concentration (Saxena *et al.*,2007) utilizing petroleum ether leaves extract of *E. globulus* against the same larval instars and seen 90% larval control which is in conformity with the present observations using different parts of these plants. Most significant mortality was recorded in 1.0% concentration of *N. indicum* seed and *E. globulus* flower extracts. However, the lower concentrations of all these extracts did not see any significant effect on larval survivality exhibiting mortality.

Table 7. Different plant extracts on the developmental period (days), adult emergence (%) and cumulative mortatlity (%) of first instar larvae of *Epilachna vigintioctopunctata*

Extracts		Concentration(%)	Developmental period(days)	Adult Emergence(%)	Mortality (%)
Plant	Parts				
Acacia arabica	Leaves	0.5 1.0	18.9 18.2	66.6 20	59 80
Eucalyptusglobulus	Flowers	0.5 1.0	20.5 17.8	60 6.6	63 90
Nerium indicum	Seeds	0.5 1.0	22.1 19.6	30 0	60 95.5

(Source: Saxena and Sharma,2012)

Impact of biorational pesticide on natural enemy

Biological control is the beneficial to parasites, pathogens, and predators in controlling pests and their damage. The development of bio-rational pesticides has focused on the efficacious management of the key pests. Their effects on natural enemies, non-target pests, and the environment is quite scanty. For other types of revealed-feeding insects, depends on contact insecticides with little or no persistence residues, including azadirachtin, narrow-range oil ,insecticidal soap, pyrethrins, and neem oil, which are mixed with the synergist piperonyl butoxide.

Table 8. Relative toxicity of biorational insecticides to natural enemies

Insecticide	Toxicity to predator and parasitoids	
	Direct	Residual
Microbial (*Bacillus thuringiensis*)	no	no
Botanicals (pyrethrins)	yes/no	no
Oil (horticultural), soap (potash soap)	yes	no
Microbial (spinosad)	yes/no	yes/no
Neonicotinoids (imidacloprid)	yes/no	yes
Carbamates (carbaryl), organophosphates (malathion), pyrethroids (bifenthrin)	yes	yes

(Source: Dreistadt, 2014)

1. Direct contact toxicity is killing within several hours from spraying the effective or its habitat. Residual toxicity is killing or sub lethal effects (such as reduced reproduction or ability to focus and kill pests) due to residues that exists.
2. Toxicity rely on the certain material and how it is applied and the species and life stage of the natural enemy.

Effect of different plant products on the population of lady bird beetle, ant and spider

Due to the application of botanicals there were no effects on the natural enemies. The number of lady bird beetle, ant and spider which were found in pitfall traps are shown in Table 5. Results showed that the number of lady bird beetle among the treatments ranged from 3.59 to 4.21 and there was no significant difference ($F_{10,44}$= 1.143, $p \leq 0.05$). There was insignificant difference ($F_{10,44}$= 1.393, $p \leq 0.05$) among the treatment in the number of ant which varied from 13.12 to 14.17 and black pepper powder had the highest number of ant (14.71). Number of spider among the treatments ranged from 3.15 to 4.37 and the result showed that there were no significant differences among the treatment ($F_{10,44}$= 1.869, $p \leq 0.05$). The insignificant variation in number of lady bird beetles, ants and spiders in different treatments might be due to the environmental and physiological reason. Hence, it could be said that the botanicals had no detrimental effect on the population abundance of the beneficial insects in the field of country bean (Ahmed, 2015).

Table 9. Effect of different plant products on the population of lady bird beetle, ant and spider

Treatment	Number after treatment		
	Lady bird beetle	Ant	Spider
Black pepper powder	3.59a	14.17a	4.37a
Chili powder	3.59a	13.12b	3.15a
Turmeric powder	4.21a	13.41ab	4.14a
Coriander powder	3.77a	13.96ab	3.46a
Mahogany oil	3.59a	13.16b	3.32a
Neem oil	4.21a	13.72ab	4.23a
Eucalyptus oil	3.27a	13.96ab	3.38a
Neem leaf extract	4.21a	13.16b	3.89a
Basil leaf extract	4.0a	14.03ab	4.23a
Garlic extract	3.27a	13.54ab	3.23a
Control	4.21a	13.14b	3.89a

Data expressed as mean ± SD. Means within a column followed by same letter(s) are not significantly different (DMRT, $p \leq 0.05$).

(Source: Ahmed, 2015)

Residue of spinosad 45 sc on brinjal fruits: The results of residue estimation of spinosad on brinjal fruits were presented in Table 10.

Residue estimation of spinosad on brinjal fruits revealed that the mean content of residue of major component of spinosad *i.e.*, spinosyn A recorded the residue of 0.104 mg/kg of fruits where as the minor component of spinosad i.e., spinosyn D showed the residue of 0.025 mg/kg of fruits.

Table 10. Residue of spinosad in brinjal fruits

Components of Spinosad	Residue of spinosad in brinjal fruits(mg/kg)			Cumulative mean (mg/kg)
	R_1	R_2	R_3	
Spinosyn A	0.091	0.092	0.129	0.104
Spinosyn D	0.029	0.016	0.032	0.025

(Source: Gowrish, 2014)

CHAPTER 4

CONCLUSION

Bangladesh's economy is extremely subjected to its agricultural sector which recorded for about 35 percent of the country's gross domestic product (GDP). Vegetable production is one of the more dynamic and major branches of agriculture, and from the point of view of economic value of the production. Insect infestation is considered the main constraint as they damage Brinjal, its cultivation helps to improve human nutrition and income generation. But the the crop attacked with various type of insect pests throughout the year. Bio-rational management becomes apparent when broad-spectrum, residual pesticides cause secondary pest outbreaks or pest resurgence. The use of natural enemy, plant products, sex pheromone traps and microbial origin insecticides can be the novel approaches to manage the pest. From different review paper results, it is clear that for brinjal shoot and fruit borer more satisfactory result was obtained through combined use of spinosad and pheromone than their individual application. For management of sucking pests (aphids, jassids, white fly, thrips and mites) botanical extracts and sticky traps (Bioneem plus 1 EC + white & yellow sticky traps) gave the most effective result and highest benefit-cost ratio(3.06).In case of spotted beetle higher concentration of *Nerium indica* was proved higer mortality rate than others. So it can be recommended that a package of spinosad, pheromone trap, sticky trap and neem based pesticide for the effective management of brinjal insect pests which are less harmful to natural enemies than conventional insecticides and also eco-friendly.

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