STUDY ON THE EFFICACY OF BOTANICALS AND SOME SELECTED PESTICIDES ON PEST COMPLEX OF CHILI (*Capsicum frutescens*)

BY

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CERTIFICATE

This is to certify that the thesis entitled, **"Study on the Efficacy of Botanicals and Some Selected Pesticides on Pest Complex of Chili (*Capsicum frutescens*)"** submitted to the Department of Entomology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY** embodies the result of a piece of bonafide research work carried out by **Md. Badal Mallik**, Registration No. 02607 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 duly acknowledged by him.

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Dedicated to
My
Departed Father

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STUDY ON THE EFFICACY OF BOTANICALS AND SOME SELECTED PESTICIDES ON PEST COMPLEX OF CHILI (*Capsicum frutescens*)

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The study was carried out in the experimental farm of Sher-e- Bangla Agricultural University, Dhaka, Bangladesh during the period from January to September 2008 to determine the efficacy of botanicals and some selected synthetic pesticides on pest complex of chili (*Capsicum frutescens*). The experiment comprises of eight treatments and among them first five (T_1, T_2, T_3, T_4 & T_5) were the application of botanicals and two others (T_6 & T_7) were synthetic pesticides. The treatments were, T_1: Neem leaf extract @ 20g/l at 3 days interval, T_2: Neem seed extract @ 20g/l at 3 days interval, T_3: Neem oil @ 15ml/l at 3 days interval, T_4: Biskatali leaf extract @ 20g/l at 3 days interval, T_5: Garlic clove extract @ 15ml/l at 3 days interval, T_6: Arozim @ 3g/l at 7 days interval, T_7: Thiolux @ 3g/l at 7 days interval, T_8: Untreated control. In total cropping season, the highest incidence (percentage) of red mites, aphids and white flies on leaves were 62.33%, 26.09% and 3.32%, respectively and the highest incidence (percentage) of fruit borer on fruits was 9.21% with the treatment T_8. On the other hand, the lowest incidence (percentage) of red mites, aphids and white flies on leaves were 24.30%, 4.06% and 0.46%, respectively and the lowest incidence (percentage) of fruit borer on fruits was 3.88% in T_3. In the whole season, the highest infestation (percentage) on leaves was 3.78% with the treatment T_8 and the lowest infestation (percentage) on leaves was 0.88% with the treatment T_3. In case of fruits, the highest infestation (percentage) was 27.20% with the treatment T_8 and the lowest infestation (percentage) was 7.76% with the treatment T_3. Fruit infestation reduction over control in weight was the highest (59.06%) with treatment T_3, while the lowest (30.59%) reduction was in T_1. The highest weight of fruit yield was 30.22 ton/ha with treatment T_3 and the lowest yield was 16.87 ton/ha with treatment T_8. As a whole, among the different treatments botanicals were more effective than the chemical pesticides.

CHAPTER 1

INTRODUCTION

Chili (*Capsicum frutescens*) is the most important spice crop over the world. It is a plant under the family of Solanaceae. In Bangladesh, the crop is grown in an area of about 66,235 hectare and its annual production is about 52,215 metric tons which is very low as compared to that of other chili growing countries in the World (Anon., 2002). The low yield of chili in Bangladesh may be attributed to a number of reasons such as unavailability of quality seeds of high yielding varieties, fertilizer management, disease and insect infestation and improper cultivation facilities.

The crop can be cultivated in both the summer and winter seasons and average yield of chili is 5 ton/hectare (BBS, 2005). It is widely cultivated in Bangladesh. As a winter crop, it is grown mostly in Comilla, Noakhali, Foridpur, Barisal, Patuakhali and Bogra. There are several local varieties like *Balijuri, Bona, Satia, Paba, Halda, Dhani, Shaikarpur,* and *Patnai*. Both green and dry chillis are used as spices for the preparation of various curries. Dry chili is an ingredient of curry powder, sauces and pickles. Green chili is rich in vitamin-C. Until the beginning of the 20th century chili was exported from Bengal on a very large scale. Among other spices chili was an attraction for the East India Company to come the eastern part of India (AKM Matiar Rahman, 2006).

Chili is susceptible to insect attack from seedling to fruiting stage. All parts of the plant including leaves, stems, flowers and fruits are subjected to attack (HDRA, 2000). About 51 species of insects and 2 species of mites belonging to 27 families under 9 orders along with snail and two species of millipedes are known to damage chili crop both in the nursery and main field. Among these pests' aphids, fruit borers, white flies and mites are of serious in nature (Muthukrishnan *et al*., 1990, Shahjahan and Ahmed, 1993). These insects and pests cause both qualitative and quantitative losses in chili in the field. (Shahjahan and Ahmed, 1993).

There are some prevailing management practices in Bangladesh to control the major pests of chili. These are chemical and non-chemical tactics. The non-chemical tactics are cultural, mechanical, physical, biological, use of light traps, pheromone traps, resistant varieties and host plant resistance. These methods are taken by the researcher through out the world to reduce the economic loss.

Generally the farmers are habituated to control these pests by using chemicals because they think pesticides are boom. It was found that 99.76% aphids, 87.22% white flies, 73.89% borers are controlled by using imidacloprid, acephate and cypermethrin @ 70g/ha, 1500g/ha and 300g/ha respectively (Kumer *et al*., 2001). In sub-continent, it was also reported that dicofol 18.5%, sulphur 80%, endosulfan 35% gave the better result in reducing 85.19% of yellow mite (Srinivasulu and Rao, 2002).But there are some limitations which hinders the chemical control. Yield losses in case of application of different chemicals were estimated at 40-100% and 15-50%, respectively in different areas of Bangladesh (Agranovsky, 1993). Application of precise dose of the chemical to the field is a difficult job for them. Moreover, indiscriminate as well as long time uses of chemicals affect the soil and human health. Harmful chemical substances enter into the food chain that ultimately causes serious health hazards. Though chemicals are effective in controlling insects and other pests but they are not cost effective.

In Bangladesh, very few research works have been done for the management of chili pests. These are mainly on chemical control, cultural control, mechanical control, development of resistant varieties and use of botanical pesticides etc.

To overcome this problems, it has been given great importance on IPM programme i.e. uses of resistant varieties or uses of safe pesticides such as botanicals in crop field. Eco-friendly management of pest such as use of botanical extracts has a great chance to save the environment from pollution. Most of the botanical extracts are also cost effective and readily available to the farmers in time. As a result botanical pesticides are becoming popular day by day. At present, these are used against many insects and pests. Use of botanical extract

against pest is a recent approach to insect management and it has drawn special attention of the Entomologist all over the world. In Bangladesh, a few attempts have been made to evaluate botanical extracts against insects' pest (Karim, 1994). Therefore, the present study was undertaken to fulfill the following objectives:

1. To know the extent of damage by the chili pests against different management practices**.**

2. To know the comparative effectiveness of different chemical pesticides and botanicals on infestation and yield of chili against pest complex of chili.

3. To explore the effective techniques among different management practices against pest complex of chili.

CHAPTER 2
REVIEW OF LITERATURE

Crops plants are usually grown in a community. Growth and development of chili plants are greatly influenced by the environmental factors (i.e. light, temperature, insects and pests etc.), variety used and various practices (i.e. fertilizer application, irrigation, weeding, pest management etc.). These factors have a great impact and effect on the growth, yield and yield component of chili. Chili is one of the important spices crop in Bangladesh and as well as many countries of the world. There are many pests of chili among them aphids, fruit borers, thrips, mites are considered as the damaging one and has profound effect on chili production in Bangladesh. The concept of management of pest employing eco-friendly materials gained momentum as mankind became more conscious about environment. Use of botanicals and chemicals are the recent approaches for pest control that was commonly practiced. The research work so far done in Bangladesh and else where is not adequate and conclusive. A brief but exhaustive review of the related works done in the recent past has been attempted below:

2.1 Effect of chemicals for controlling pest

Ukey *et al*. (1991) used monocrotophos, triazophos, methyl demeton, quinalphos, cypermethrin, deltamethrin, fenvalerate, permethrin and deltaphos for the control of *Eurytoma sp*. and the eulophids *Goethella* sp. and *Ceratoneura indi* on *Capsicum annuum* in Maharashtra, India Monocrotophos 36 WSC at 0.05%was the most effective treatment, followed by 0.02% demeton-methyl 25 EC. The best yield and monetary returns were obtained with these treatments.

Frank *et al*. (1992) carried out an experiment to determine effects of weed-interference periods and insects on *C. annuum* cv. Yolo Wonder. Weed interference for approx. 40 and 60 d reduced both fruit number and wt by 10 and 50% respectively. *C. annuum* foliage wt was reduced by 10 and 50% with approx. 20-and 50-d weed-interference periods, respectively. In 1985 and 1986, insect

populations were low, with an av. of 10 and 3% of the fruit infested, respectively. Most infested fruit was damaged by European corn borer (*Ostrinia nubilalis*). No differences in insect infestation of fruit as related to time of weed interference periods were noted.

Nelson and Natarajan (1994) carried out an experiment during a field trial, the moult inhibitor diflubenzuron and a nuclear polyhedrosis virus reduced damage by fruit borers on chilies. In plots treated with diflubenzuron, Larval/pupal intermediaries were observed.

Nelson and Natarajan (1994) carried out studies for observations were made on fruit borer populations, damage, fruit set percentage and yield of chilies. A regression equation was obtained to relate damage score to yield loss. Yield losses of up to 50% were observed due to fruit borer damage. Even at the lowest population density observed (2/plant), spraying with dimethoate is recommended to reduce yield losses.

Kumar (1995) studied that quantitative yield loss was maximum in chili pepper in contrast to qualitative yield loss caused due to scarring by thrips on sweet pepper. More than 90% yield reduction was observed on chili pepper compared to 11-32% in sweet pepper because of thrips infestation. Qualitative yield loss of 88-92% was observed in sweet pepper. A highly significantly negative correlation between marketable yield (fruits free of scarring damage) and rating for thrips damage on different days after transplanting was observed in sweet pepper. Total yield was not significantly correlated with damage ratings on different days after transplanting in sweet pepper but was correlated in chili pepper. Retention of dry sepals after fertilization on developing fruits influenced qualitative yield loss in sweet pepper.

Mallapur *et al*. (2001) conducted an experiment to evaluate the efficacy of the premix, Match (difenzoquat) + profenofos (at 1 and 1.5 litre/ha), against chili (*Capsicum annuum*) cv. Dyavanur Deluxe fruit borer *Helicoverpa armigera*. The treatment efficacy was compared with profenofos at 1.5 litre/ha, the standard

control (cypermethrin at 0.5 ml/litre) and the recommended package (carbaryl at 3.0 g/litre). Two sprays were supplied at an interval of 20 days after appearance of pod borers. The highest larval mortality was observed in plots treated with cypermethrin, followed by Match + profenofos. Fruits whithening was also low in cypermethrin treated plots followed by the premix. The highest yield was obtained by cypermethrin followed by the premix at 1.5 litre/ha.

Kumar *et al*. (2001) conducted the bio-efficacy of triazophos (350 or 700 g/ha), acephate (1000 or 1500 g/ha), cypermethrin (150 and 300 g/ha) and imidacloprid (50 or 70 g/ha) against the major pest complex (aphids, *Myzus persicae*, thrips, *Scirtothrips dorsalis*, gram pod borer, *Helicoverpa armigera*, tobacco caterpillar, *Spodoptera litura*, and sunhemp hairy caterpillar, *Utetheisa pulchella*) of chili (*Capsicum* spp.) was evaluated in a field experiment conducted in Rajendranagar, Hyderabad, Andhra Pradesh, India during kharif season of 1997-98. Imidacloprid (70 g/ha) was the best treatment in controlling aphids (99.76% reduction). Acephate (1500 g/ha) was the most effective in controlling thrips (87.22% reduction). Cypermethrin (300 g/ha) was generally the most effective insecticides against borers.

2.2 Effect of botanicals for controlling pest

2.2.1 Effect of plant extracts for controlling mite pest

Banu *et al*. (2007) conducted an experiment to compare some non-chemical approaches to control yellow mite and in greenhouse and field condition. In greenhouse condition, double spray of green neem leaf extract @ 1:20 and dry neem leaf @ 1:50 was found to be effective and gave 74.63% and 70.83% mortality 72 hours after treatment on potted plants. However, in field condition, double spray of green neem leaf extract and dry neem leaf extract gave 67.70 % and 72.20% reduction of infestation 7^{th} day after spray.

Materska *et al.* (2006) found that application of different chemical; imidacloprid, chlorfenapyr, abamectin, cyfluthrin and methiocarb and plant extract; neem oil

(*Azadirachtin*), karanja oil *(Pongamia glubra),* Mahua oil *(Madhuca lalifolia)* for pipper yield. Neem oil was the best protector compared to other chemical and botanicals protector in respect of biological yield. They also reported that botanical insecticides were more favorable than chemical control and environment friendly.

Frantz *et. al.* (2004) conducted a greenhouse experiment with pepper (*Capsicum* spp.) on aphid infestation. There were significant differences among accessions for damage rating, number of aphids/plant and number of aphids/leaf. To remove aphids, chemicals (cypermethrin, 250 g/ha) and botanicals (green neem leaf extract @ 1:15, dry neem leaf @ 1:40 and neem oil @ 1: 50) were used. Botanicals were more effective (60%, 70% and 75% respectively) than chemicals (55%)

Pasini *et al.* (2003) studied the effect of commercially formulated neem oil (Azadirachtin) at different stages of the life cycle of the red mite of Paragua tea. They found that formulation was efficient in controlling adults. Azadirachtin also affected the fecundity of the female mites.

Simkin *et. al*. (2003) conducted an experiment to evaluate yield effectiveness depending on different growth stages and fruiting stages varied on the attack of insect and pests on growth stages and fruiting stage respectively. It was observed that attack of pest on growth stages was more harmful for effective yield. It was also observed that population number was decreased remarkably where growth stage of plant was attack with pest than the attack of fruiting stage.

Weintraub *et. al*. (2003) found that neem leaf extract (2%), neem seed kernel (5%) and cold pressed neem oil reduced the white fly infestation on treated plants and inhibited eggs hatches. Application of neem oil in high concentration caused maximum control on the nymphal stages and adult stages.

Palaniswamy and Ragini (2000) sprayed 5% aqueous extracts of *Adathoda vasica,*

Vitex neegundo, Azodirachta indica, Aristolochia bracteata, Lippia nodiflora,

Argemone mexicana sansevieria sp. and *Aloe sp. on* chillies 30 days after transplanting in Tamil Nadu, India. The *Polyphagotarsonemus latus* populations were reduced and Aloe sp. was also recorded to be the lowest.

Diemetry, *et al*. (1996) stated that the high concentration of all the tested extracts exhibited positive response where tomato plants (variety UC-97) were cultivated in pots and left to become naturally infested with *Bemisia tabaci* in an open field and were sprayed with various concentrations of extract.

Saibllon *et al*. (1995) studied the effects of extracts from *Ricinus communis, Melia azadarach, Azadiracta indica,* and a tobacco derived commercial product against *Bemisia tabaci*. None of the treatments controlled *Bemisia tabaci,* but numbers were reduced on neem treated plants and these plots gave higher yield than others.

Pal and Basu (1993) conducted an experiment on high vigour (freshly harvested) wheat cv. Sonalika seeds were mixed with powdered air-dried red chilli (*Capsicum frutescens*) at 0.1-0.5 g/kg seed, turmeric (*Curcuma domestica*) at 0.2-1.0 g, or neem (*Azadirachta indica*) at 0.2-1.0g. Results of germination tests conducted 7 days after treatment showed that treated and untreated seeds gave 100% germination but total seedling length was greater for treated seeds, especially those treated with neem. After accelerated aging at 98% RH and 40 degrees C, 56.2% germination of untreated seeds was recorded, whilst germination rates in treated seeds were 15-20% better (70.9-76%), and seeding growth was increased 30-35%. Treated wheat seeds stored for 7 months under ambient conditions produced lower level of aldehyde than untreated seeds.

Chitra *et al*. (1993) reported that extract of leaves of *Argemone mexicana* (0.1%), leaves of *Azadirachta indica* (0.1%) and neem guard (0.5%) gave 76.18%, 69.55% and 55.92% control over untreated control, respectively.Sanguanpong and Schmutterer (1992) found that pentane extract and cold pressed neem oil reduced the fecundity of the mites on treated plants and the survival of nymph hatched from treated eggs. Application of pentane extract or neem oil in sub lethal

concentration caused growth disrupting effects on the nymphal stages and ovicidal effects.

Pande *et al.* (1987) reported that neem leaf extract (1%) and neem seed kernel (5%) was very effective against *Tetranychus neocaledonicus* and *Tetranychus urticae* respectively. This result was also supported by Devraj (1990).

2.2.2 Effect of plant extracts for controlling pests

Doolittle *et al*. (2007) tested the effect of some natural products on gut microbes in Farmosan subterranean termite *(Coptotermes formosanus).* They used three natural products (neem extract, capsaicin and gleditschia) to reduce the number of Formosan subterranean termite (FST) hindgut microbes *(Pseudotrichonympha grassii, Spirotrichonympha leidyi* and *Holomastigotoides hartmanni)* and found neem extract was capable of reducing the population of *Pseudotrichonympha grassii* and spirochaetes.

Singh (2006) tested the efficacy of some spices and plant products on the incidence of rice gundhi bug, *Leptocorisa* spp. (Alydidae: Hemiptera). He found neem oil, neem seed kernel and neem seed kernel powder were effective to protect the crops by reducing bug population as per conventional insecticide treatment.

Prabhat, Kumar and Poehiling (2006) studied persistence of soil and foliar azadirachtin (neem based product) treatments to control sweet potato whitefly *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae) on tomatoes under controlled (laboratory) and field (netted greenhouse) conditions in the humid tropics. Two commercial neem products, Neem Azal Reg.- T/S (1% azadirachtin) and Neem Azal Reg.- U (17% azadirachtin) were used. Foliar application, under room conditions at dose-rates of 7 and 10 ml Neem Azal Reg.- T/S induced an immature mortality of 32 and 44%, respectively. Systemic application by soil drenching with solutions of 3.0 g Neem Azal Reg.- U until 7 day, immature mortality declined from 88% for the first day to

almost half (45%) by day-7 in the GH, and from 90% on first day to 64% by day-7 under laboratory condition. Similar response trends for *B, tabaci* were obtained for other parameters such as adult colonization, egg deposition, and egg hatch.

Abdullah *et al.* (2006) evaluated neem cake, Nembicidine, neem leaf powder and Bishkatali *(Polygonum hydropiper)* plant powder and tobacco plant powder against some major insect pests of sugarcane. They found that all botanical products reduced larval population and infestation caused by top shoot borers *(Scirpophaga excerptalis)*, stem borer *(Chilo tumidicostatis)* and rootstock borer *(Emmalocera depressella[Polyocha depressella])*.

Gonzalez Gomez *et al.* (2006) conducted an experiment to evaluate the acute toxicity of crude neem seed extract and neem based commercial product (0, 1, 2, 3 and 4%) on Varroa destructor (Aceri: Varroidae) and *Apps mellifera* and repellence of varroa mites. They found neem based products had a persistent repellency effect that lasted approximately 48 h.

Jagjeet *et al.* (2005) treated pigeon pea seeds with 11 seed protectants, i.e. neem seed kernel powder at 20 g, neem oil at 10 ml, mustard oil and groundnut oil each at 7.5 ml, turmeric powder at 3.5 g, mustard oil + turmeric powder at 3.7 ml + 1.75 g, groundnut oil + turmeric powder at 3.7 ml + 1.75 g each per kg of seed. All the seed protectants, expect sawdust and turmeric powder, recorded significantly higher adult mortality than the control after the first day of treatment. Neem oil was found most effective (64.33% adult mortality) up to 35 DAT and it were followed by mustard oil + turmeric powder, giving 16.33% adult mortality.

Zhu *et al.* (2004) studied the biological activity of azadirachtin on rice stem borer, *Chilo suppressalis*. After feeding on water oats treated with 0.75 and 0.50 mg azadirachtin/litre, the third instar larvae had completely died after 3 and 6 days, respectively. Mortality of the newly hatched *C. suppressalis* reached 100% within 24 h after treatment.

Manju and David (2004) studied the effect of soil and foliar application of neem products on densities of egg masses of the yellow stem borer, *Scirpophaga incertulas* infesting rice, and on the extent of egg parasitism by *Teienomus* by *Tetrastichus scoenobil.* NPK fertilizers and organophorphate insecticides were included for comparison. The egg masses were higher in NPK plots (2.16 m^{-2}) than in neem cake plots (1.10 m^{-2}), whereas parasitism was higher on plants sprayed with neem products + fish oil rosin soap (26.28%) in neem cake plots than on plants with no plant protection in NPK plots (20.92%).

Prasad *et al.* (2004) evaluated neem products against yellow stem borer, *Scirpophaga incertulas* on deep water rice and found significantly better than the untreated control. Neemgold Liquid at 2.0% was the most effective neem product and was at par with the standard insecticide, as it recorded very low damage percentage (1.4, 1.6 and 3.8%) and higher yield (13.86, 11.89 and 24.24 tea).

Madathir and Basedow (2004) conducted an experiment to study the effect of neem products on pests and yields of okra *(Abelmoschus exculentus)*, *tomato (Lycopersicum esculentum)* and onion *(Allium cepa)* in the Sudan. In okra, the neem preparations were significantly reduced the attack of the 4 pests studied i.e. *Aphis gossypii, Bemisia tabaci, Earias vittella and Podagrica puncticollis*, in 1998. In tomato, *Lirimyza trifolii was* significantly reduced by both neem preparations, while *A. gossypii* and *B,tabaci* were controlled only by NKWE and Neemazal, respectively. However, there was no effect of neem preparations on pest and yield of onion.

Maisary and Rahawi (2004) conducted an experiment to examine the effect of neem oil on the 2nd and 4th instars and eggs of *Culex pipiens* under laboratory condition. They observed that 46.98% of C. *pipiens* were killed upon exposure to 1000 ppm of neem oil. However, the lower concentration (10 ppm, 100 ppm) showed little efficiency on the eggs. The continuous treatment of the 2nd

and 4th instars with neem oil (100 ppm) caused high mortality and complete inhibition of the formation of mature instars. Based on these results, they concluded exposure to neem oil for a short period (24 and 48 h) is less effective as compared with continuous.

Eungwijarupanga *et al*. (2002) tested neem extracts containing 0.185% azadirachtin at 3 concentrations 100 ml, 200 ml and 300 ml, diluted in 5 litres of water. These were applied using a thermal fogger to a 15 years old teak *(Tectona garandis)* for control of teak defoliator, *Hybiaea puera.* After application larvae were collected and reared in the laboratory to observed mortality. One day after, laboratory fogging mortality started to increase for these treated with 200 ml and 300 ml/5L concentrations and all larvae died within 6 days when treated with 300 ml/5L.

Padmasheela and Delvi (2002) tested a commercial formulation of neem oil (Nimbex, 0.3%) at different concentration viz. 25 ppm, 50 ppm, 75 ppm and 100 ppm for mortality effects against grubs of *O. rhinoceros* (a coconut pest) at laboratory conditions. In feeding toxicity test, neem oil at concentrations of' 50 ppm, 75 ppm and 100 ppm caused 20%, 45% and 90% mortality, respectively on exposure up to 96th day/100 ppm caused 90.67% mortality.

Sundarajan (2002) conducted methanol extracts of selected plants namely *Anisomeles malabarica, Ocimum canum, O. basilicum, Euphorbia hirta, E. heterophylla, Vitex negundo, Tagetes indica* and *Parthenium hysterophorus* have been screened for their insecticidal activity against the fourth instar larvae of *H. armigera* by applying dipping method of the leaf extracts at various concentrations (0.25, 0.5, 1.0, 1.5 and 20) on young tomato leaves. The larval mortality of more than 50% has been recorded for all the plant extracts in 2 per cent test concentration (48 h) except *E. heterophylla* which recorded 47.3 per cent mortality in 2 per cent concentration. Among the plant extracts tested *V. negundo* is found to show higher rate of mortality (82.5%) at 2 percent concentration.

Malinowaki (2002) studied the activity of azadirachtin @10 g/litre against 3rd

instar Neodiprion serlifen larvae, using aqueous emulsion at four different azadirachtin concentration (0.01%, 0.001%, 0.0001% and 0.00001%) larvae were fed with treated pine twigs for 3 days and then reared on untreated foliage until pupation. Mortality was significantly increased up to 100%, even at the lowest concentration of azadirachtin (0.00001 %).

Qureshi *et al.* (2002) investigated the direct effect of neem extracts on the adult glass beetle, *Costelytra zealandica.* Laboratory bioassay showed that neem caused only low mortality even at the highest dose.

Karmakar and Bhole (2001) observed the efficacy and persistent toxicity of some neem products neem of 1 and Nimbicidine against adult of *Epilachna dodecastigma.* The treatments of 2% neem oil and 2% Nimbicidine resulted 90.69 % and 71.90% mortality respectively.

Sundararajan (2001) carried out toxicological studies to evalute the effect of leaf methanolic extracts of 5 indigenous plant materials namely, *Abutilon indicum, Achyranthes aspera, Ailanthus excelsa, Alstonia venenata and Azima tetracantha* against *Helicoverpa armigera*. Larval mortality on tomato leaves treated with *Azima tetracantha, Achyranthes aspera, Abutilon indicm, Ailanthus excelsa and Alstonia venenata* averaged 51, 58, 62, 67 and 73%, respectively.

Imtiaz *et al. (*2001) studied the effects of neem leaf extracts on adult rice weevil, *Sitophilus oryze.* Glass film method was adopted to determine the LC50 rate. After plotting a graph between mortality and concentration, the LC_{50} was found to be 0.44 µg/sq. cm.

Kulat *et al.* (2001) carried out an experiment on extracts of some indigenous plant materials, which are claimed important as pest control like seed kernels of neem, *Azadiracta indica*, *Pongamia glabra* (*P. pinnata*), leaves of tobacco, *Nicotiana tabacum* and indiara, a neem based herbal product, against *H. armigera* on chickpea cv. I.C.C.V.5 for its management in Rabi seasons. The results revealed that the crop treated with the leaf extract of *N. tabacum* and seed extract of *P.*

glabra (5%) and indiara (1%) and neem seed kernel extract (5%) exhibited low level of population built up compared to control.

Shaminathan and Jayaraj (2001) conducted two experiments to evaluated botanical pesticides like Ipomoea and vitavex, leaf extracts, neem oil and madhuca oil (at 0.3% or 3.0% each) against *Perrisia virgata*. The leaf dip method was used in both experiments and pest mortality was recorded at 24^{th}, 48^{th} and 72^{nd} after treatments. In experiment 1, treatments with 3 % neem oil recorded the highest mortality (43.13%). Neem resulted 50% mortality at 72^{nd} and in experiment 2; at 48 h fortified (0.3%) neem oil recorded a maximum mortality of 49.3% and at 72 h, fortified neem recorded 63.6% mortality.

Ju *et al*. (2000) conducted six desert plants chosen to study their toxicity and effects on the growth and metamorphosis of the insect pest *Heliothis armigera* (*Helicoverpa armigera*). An artificial diet containing 5% aqueous extracts of *Cynanchum auriculatum* or *Peganum harmala* var. multisecta showed strong toxicity to the larvae and caused mortality of 100% and 55%, respectively. These two extracts at the same dosage also significantly affected metamorphosis of the insect. An artificial diet containing 1% aqueous extracts of *C. auriculatum* or 5% aqueous extracts of *P. harmala* resulted in mortality of 85% and 55%, respectively, and a zero emergence rate. The other plant species tested were *Euphorbia helioscopia, Sophora alopecuroides, Peganum nigellastrum and Thermopsis lanceolata*; extracts of these species caused either much lower mortality of *H. armigera* or zero mortality (*E. helioscopia*).

Prabal *et al*. (2000) conducted an experiment to know the efficacy of leaf (5 or 10%) and seed kernel (5%) extracts of neem (*Azadirachta indica)* and leaf extract (5 or 10%) of *Ageratum* sp. and a formulated fish product (5%) was tested under laboratory condition against bean aphid, *Aphis craccivora* by. All the treatments showed significantly better nymphal mortality than the control. The maximum

aphid mortality (97.50%) was observed at neem seed kernel extract, followed by neem leaf extract at 10% (61.88%).

Sundarajan and Kumuthakalavalli (2000) conducted Petroleum ether extracts of the leaves of *Gnidia glauca* Gilg., *Leucas aspera* Link., and *Toddalia asiatica* Lam. tested against sixth instar larvae of *Helicoverpa armigera* (Hubner.) at 0.2, 0.4, 0.6, 0.8 and 1.0% by applying to bhendi (okra) slices. After 24 hours, percentage of mortality, EC50 and EC90 were calculated. Total mortality was recorded in the treatment with 0.8% of the extract of *G. glauca.* Of the three leaf extracts used, *G. glauca* showed an EC_{50} of 0.31%.

Menhajul (1999) observed that the effect of neem oil on the 3^{rd}, 4^{th} and 5^{th} instar larvae of Jute hairy caterpillar. He found 30% to 100% larval mortality up to l0% concentration of neem oil,

Reddy *et al.* (1999) stated that application of four plant neem oil (Azadirachtin), karanja oil *(Pongamia glubra),* Mahua oil *((Madhuca lalifolia)* and palmolein oil *(Elaeis gaineenis)* at dosages of 0.5% and 1.0% level effectively protector green gram from C. *chinensis.* Neem oil at 1% level was the best protector followed by Palmolein, Karanja and Mahua oils. These oils also exhibited contact toxicity and no adults could survive in neem treated green gram at 5% concentration.

Tabassum *et al.* (1999) reported that the toxicity of neem compound (Nfc and NC) and an insect growth regulator dimilin (diflubenzuron) were determined against adult of the pulse beetle, *Callosobruchus analis using* filter paper impregnation and glass film method. The LC_{50} values of Nfc, NC and dimilin were 39.20 µm/cm^2 7.17µm/cm^2 and 13.5 µm/cm^2 respectively, using the filter paper impregnation method, while 10.0 µm/cm2 and 4.9 µm/cm^2, respectively, for NC and dimilin using the glass film method.

Khorsheduzzaman *et al.* (1998) reported that neem oil @ 30 ml/l of water can provide 41.11% infestation over control by the brinjal shoot and fruit borer. The

neem oil provided 49.1% brinjal shoot and fruit borer infestation reduction over control.

Gopal *et al.* (1997) carried out and experiment to determine the efficacy of insecticides (endosulfan and diflubenzurun), neem products and nuclear polyhedrosis virus (NPV) alone or in combination for the control of fruit borer, *Helicoverpa armigera*, on tomatoes. Neem seed kernel extract (NSKE) 3% + endosulfan 0.035% + NPV at 250 larval equivalents (LE) ha^{-1} applied 3 times at 45,55 and65 days after planting gave the highest larval mortality, reduced fruit damage, and the highest fruit yield.

Mahapatro and Umakanda (1998) found that the green leaf hopper *(Nephotettix virescens)* population can be better managed by integrating neem derivatives (neem oil and neem seed extract 0.2% along with 0.1 % teepol) at 20 and 70 days after transplanting (DAT) with chemicals such as monocrotophos (0.4 kg a.i./ha) as an intermediate spray at 40 DAT.

Botanical pesticides are becoming popular day by day. It was found that Lepidopteran insect is possible to control by botanical substances. Weekly spray application of the extract of neem seed kernel has been found to effective against *Helicoverpa armigera* (Karim, 1994). The leaf extract of neem tested against the leaf caterpillar of brinjal, *Selepa docilis* but at 5% concentration had a high antifeedent activity (Jacob and Sheila, 1994).

Solsoloy and Solsoloy (1987) stated that cottons bolls treated with 2% neem oil emulsified with 1 % surfactant inhibited the feeding of even starved larvae of cotton bollworm. The amount of frass they excreted was significantly lower than the control which was sprayed with acetone. Similarly, the larvae were relatively lighter and smaller. These results showed the antifeedant effect of the oil.

Unchalle (1987) observed the efficacy of neem oil on rice leaf hopper, *Nephoteti viirscens.* The repellent property of neem oil was found to increase

along with the increasing oils concentration. Neem oil at 7% concentration and above was observed to reduce the population density to treated 3rd instar nymphs of green leaf hopper to more than 50%. Twenty five percent neem oil was found to decrease mortality of female green leafhopper to lower than 50% after 6 days of spraying.

Kareem and Durairaj (1987) evaluated crude extracts of neem seed kernel (NSK) and neem cake (NC) in water and neem oil (NO) emulsion along with two synthetic insecticides in fields as foliar sprays for the control of major insect pests of rice. NSK 4% significantly reduced green leaf hopper (GLH), Brown Plant Hopper (BPH) and White Backed Plant Hopper (WBPH) populations and leaf folder (LF) damages in two fields trials proving either as per with or next in efficacy to fethion and phosphamidon spraying.

Saxena and Khan (1986) monitored feeding behavior of *N, virescens* on rice plants kept in an arena permeated with the odour of neem seed oil. The garlicky odour of neem oil disrupted the normal feeding behavior of Cicadellids. Phloem feeding by *N. virescens* on rice plants kept in arena permeated with odour of 6.12 or 25% neem oil was significantly reduced.

Heyde *et al.* (1983) found that 2 to 4 days exposure of *Sogatella furcifera* to plants treated with 500 ppm of neem seed kernel extracts resulted in 75% mortality where as in the control, mortality was only 5%. On third instar, *N. lugens* nymphs, a combination of foliar and topical application induced higher mortality (75%) than either application alone (30%).

Schmutterer *et al*. (1983) studied the motphogenetic effects of four partially purified fractions of neem seed extracts and two methanolic seed extracts on larvae of rice ear cutting caterpillar, *Mythimna separeta* walker and the rice leaf folder, *C. medinalis* larvae fed for 24 h. On rice leaf cuts dipped in different solution of the partially purified fractions and methanolic extracts exhibited pronounced development abnormalities and mortalities in succeeding larval instars and in pupal and adults stages.

CHAPTER 3
MATERIALS AND METHODS

The experiment was conducted in Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from January to September 2008 to determine the efficacy of some selected pesticides and botanicals on pest complex of chili. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout of the experimental design, intercultural operations, data recording and their analyses under the following headings and sub-headings:

3.1 General Considerations:

3.1.1 Geographical Location

The experimental area was situated at 23°77'N latitude and 90°33'E longitude at an altitude of 8.6 meter above the sea level (Anon., 2006).

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract'", AEZ-28 (Anon, 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands' surrounded by floodplain (Anon., 1989b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The research area was under the subtropical climate and characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information of experimental site regarding temperature, relative humidity, rainfall

and sunshine hours prevailed during the study period was presented in Appendix II.

3.2 Characteristics of soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.1-6.3 and had organic matter 1.29%. The study area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.3 Planting materials

The 30 days old plants were collected from Sher-e-Bangla Agricultural University Campus (Department of Horticulture and Post Harvest Technology), Dhaka and transplanted in the main field.

3.4 Treatments of the experiment

The experiment comprised with eight treatments including an untreated control plot. Among the 8 treatments, (T1 $-T_5$) treatments were with the botanicals and (T_6 & T_7) treatments were with the application of chemical pesticides. The details of the treatments are presented below:

T_1: Neem leaf extract @ 20 g/l at 3 days interval

T_2: Neem seed extract @ 20 g/l at 3 days interval

T_3: Neem oil @ 15 ml/l at 3 days interval

T_4: Biskatali leaf extract @ 20 g/l at 3 days interval

T_5: Garlic clove extract @ 15 ml/l at 3 days interval

T_6: Arozim @ 3 g/l at 7 days interval

T_7: Thiolux @ 3 g/l at 7 days interval

T_8: Control

3.5 Collection of botanicals and its extraction mechanism

The prepared extracts of different botanicals with their raw materials are shown in plate (1-5).

3.5.1 Preparation of garlic clove extract

Garlic is an important botanical to control pest of chili. Fresh 1 kg of garlic was collected from Agargaon Bazar, Sher-e-Bangla Nagar, Dhaka. Then it was grinded by a blender. The extraction was made up by juicy cloves and it was applied in the field @ 15ml/l at 3 days interval.

3.5.2 Preparation of biskatali leaf extract

Biskatali is a vital botanical which is the most effective to control pest. The fresh leaves of this plant were collected from Shere-e- Bangla Agricultural University campus. Then the fresh leaves were grinded by a blender. Then the extract was prepared and applied in the field @ 20g/l at 3 days interval.

3.5.3 Preparation of neem leaf extract

Fresh green leaves were collected from Sher-e-Bangla Agricultural University campus. Then the fresh leaves were grinded by a blender. The extract was made up @ 20g/l. Neem leaf extract was applied in the field at 3 days interval.

3.5.4 Preparation of neem seed or kernel extract

The dried neem seed was collected from Sher-e-Bangla Agricultural University farm. The dried seed were grinded by a blender. The grinded seeds were made up extract @ 20 g/l. The extract was applied in the field at 3 days interval.

3.5.5 Preparation of Neem oil

Generally oil does not dissolve in water. So in order to dissolve neem oil in water 5ml Trix was added with 15ml neem oil. Then Trix mixured neem oil was dissolved in 1 liter of water. It was applied @ 15m/l at 3 days interval.

3.6 Collection of chemical pesticides

Arozim and Thiolux are chemicals under sulpher group of pesticides. Trade name is same of this chemical name.These were collected from Bangladesh Jute

Research Institute, Sher-e-Bangla Nagar, Dhaka. Both pesticides were dissolved by 3g in 1 liter of water and applied in the main field at 7 days interval. .

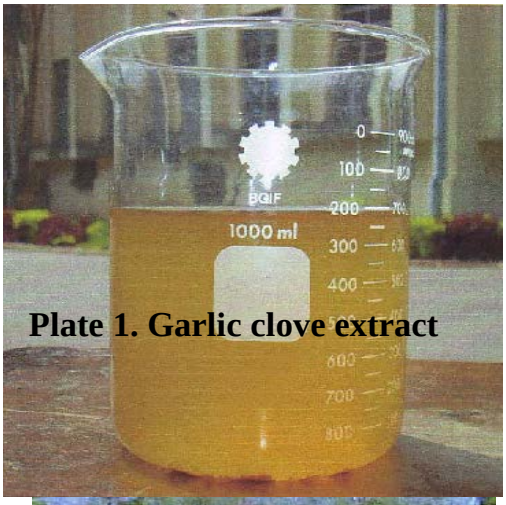


Plate 1. Garlic clove extract

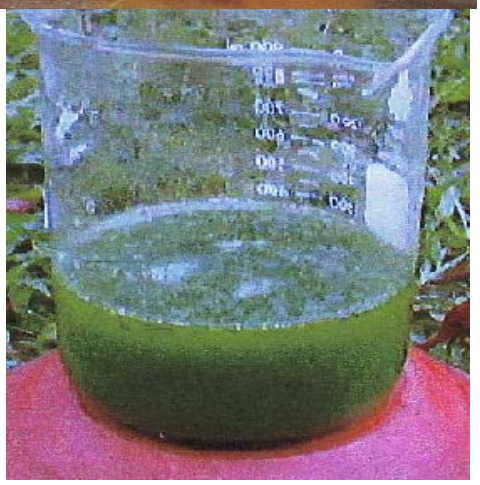


Plate 2. Biskatali leaf extract

A

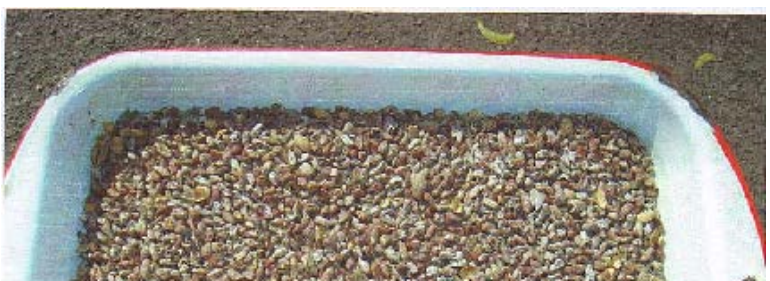
B

Plate 3.

A. Fresh neem leaf

B. Neem leaf extract

A



B

B

Plate 4.

A. Neem seed kernel extract

B. Neem seed kernel

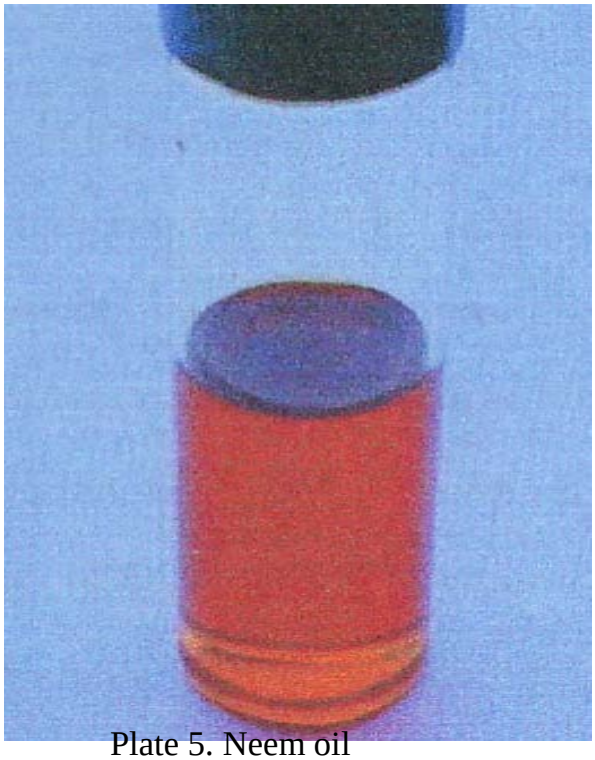


Plate 5. Neem oil

3.7 Design and layout of the Experiment

The experiment was laid out at Randomized Complete Block Design (RCBD) with three replications. The treatments were distributed in each plot of each block. There were 24 unit plots altogether in the experiment. The size of the plot was 3.0 m × 1.5 m. Seedlings of chili were transplanted in the field with maintaining spacing 40 cm × 25 cm row to row and plant to plant distance, respectively. The distance between block to block and plot to plot was 1.0 m and 0.5 m, respectively.

3.8 Preparation of the main field

The selected field for conducting the experiment was opened in the second week of December 2007 with a power tiller and was exposed to the sun light for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to ensure a good tilth for well growth and development of chili seedlings. Weeds and stubbles were removed and finally obtained a desirable tilth of soil. The experimental field was partitioned into the unit plots in accordance with layout and design.

3.9 Application of manure and fertilizers

Well decomposed cow dung (10 t/ha) was applied at the time of final land preparation. The sources of fertilizers used for N, P, K, S and Zn were urea (410 kg/ha), TSP (300 kg/ha), MP (200 kg/ha), Gypsum (110 kg/ha) and Zinc sulphate (15 kg/ha), respectively (Rashid, 1993). The entire amounts of TSP, MP were applied during final land preparation. Only urea was applied in three equal installments at 30, 45 and 60 Days after transplanting (DAT).

3.10 Intercultural operation and irrigation

After establishment of seedlings, various intercultural operations were accomplished for better development. Light over-head irrigation was provided with a watering can to the plots immediately after transplanting of seedling. Flood irrigation was also applied several times considering the moisture status of field Weeding was done whenever necessary considering to make the environment not suitable for the pests in the plots.

3.11 Data collection

Data were recorded on healthy and infested plants at different stage and yield of chili to find out the efficacy of treatments. The following data were collected during the experiment

A. Field data

a) No. of branch/plant

b) No. of leaf/branch

c) No. of infested leaf/branch

d) No. of infested leaf/plant

e) No. of healthy leaf/branch

f) No. of insects/leaf

g) No. of predators/ plant

h) No. of fruits/branch

i) No. of infested fruit/branch

j) Weight of healthy fruit/plant

k) Total weight of fruit/plot

B. Calculated data

a. Infestation with pest complex

Total number of healthy and infested leaves and fruits from 5 selected plants from each plot were recorded at different stages. Infestation was recorded at each observation were pooled and finally expressed in percentage.

The percentage of damages was calculated using the following formula:

$$\% \text{ leaf infestation (by number)} = \frac{\text{Number of infested leaves}}{\text{Total number of leaves}} \times 100$$

$$\% \text{ fruit infestation (by number)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

$$\% \text{ fruit infestation (by weight)} = \frac{\text{Weight of infested fruits}}{\text{Total weight of fruits}} \times 100$$

Increase or reduction over control was calculated using the following formula:

$$\text{Percent increase over control} = \frac{\text{Value in treated plot} - \text{value in control plot}}{\text{Value in control plot}} \times 100$$

$$\text{Percent reduction over control} = \frac{\text{Value in control plot} - \text{value in treated plot}}{\text{Value in control plot}} \times 100$$

3.12 Yield of chili

3.12.1 Yield per plot

The data on the weight of healthy and infested fruits for each treatment from whole plot along with their number and weight were recorded.

3.12.2 Yield per hectare

The weight of fruits for each treatment from whole plot weight was recorded at each harvest. The plot yield was transformed into fruit yields in ton per hectare.

3.12.3 Benefit Cost Ratio (BCR)

Benefit cost ratio was calculated by the estimation of different pest management cost with adjusting with the control condition. Mathematically,

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Net return per hectare (Tk.)}}$$

3.13 Statistically analysis

The data obtained for different parameters were statistically analyzed to find out the significance for different chemicals and botanicals that were used as treatments. The analysis of variance was performed by using MSTAT-C Program. The significance of the difference among the treatment combinations means was estimated by DMRT (Duncan's Multiple Range Test) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4
RESULTS AND DISCUSSION

The present experiment was conducted to determine the comparative efficacy of botanicals and some selected pesticides against different pests of chili that caused damage of leaves and fruits. The results of infestation of chili leaves, fruits by the pest complex (by number and by weight) and yield under the study have been presented, discussed, and possible interpretations also given below with the following headings and sub-headings:

4.1 Effect of different treatments on red mite

4.1.1 Number of red mites/plant

The results on the effect of botanicals and different pesticides in controlling red mites showed statistically significant variation by number (Table 1 and appendix v). The lowest number of red mites per plant (248.21) was recorded from the treatment T_3 as Neem oil @ 15ml/liter of water. On the other hand, the highest number of red mites (392.50) were recorded from untreated control (T_8) which was closely followed (365.90) by the treatment T_2 (Neem seed extract @ 20g/liter of water) but significantly different from untreated control T_8. The results (no of red mites per plant) recorded from the treatments T_1, T_4, T_5, T_6 and T_7 were ranged from 284.30 – 321.30. It was observed that among the different treatments under study, Neem oil @ 15ml/l reduced red mite population more effectively than the other treatments.

4.1.2 Percent (%) red mites per plant

The lowest percentage of red mites per plant (24.30%) according to the presence on leaves/plant was recorded from the treatment T_3 (Neem oil @ 15ml/l). On the other hand, the highest percentage (62.66%) was recorded from T_8 (untreated control) which was closely followed by the treatment T_2 (56.66%) as the application of Neem seed extract @ 20g/l but significantly different from T_8. The results recorded from the treatments T_1, T_4, T_5, T_6 and T_7 have the intermediate

level of effectiveness (Table 1). From the findings it was revealed that treatment T_3 performed maximum healthy leaves and minimum infestation as well as lowest % of mite infestation by number whereas in control treatment the situation was reversed. Among the different treatments as a whole, Neem oil @ 15ml/l was more effective than the other treatments under the present study.

Srinivasulu *et al*. (2002) found another comparative finding. They evaluated of different pesticides for the control of yellow mite on chili. Among the applied pesticides Abamectin (.05%) and Dicofol (.1%) were the most effective with 85.19% and 83.18% reduction, respectively.

Table 1. Effects of botanicals and chemical pesticides on the incidence of red mite in chili

Treatments	Number of red mites/plant	Percent (%) red mites on leaves/plant
T_1	321.30 c	49.00 c
T_2	365.90 b	56.66 b
T_3	248.21 f	24.30 h
T_4	302.01 d	40.07 e
T_5	284.30 e	29.99 g
T_6	305.60 d	43.33 d
T_7	293.20 de	33.99 f
T_8	392.50 a	62.66 a
$LSD_{0.05}$	13.87	1.782
CV (%)	7.52	6.39

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

In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval

T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

Pasini *et al*. (2003) studied that the effect of commercially formulated neem oil (Azadirachtin) @ 10, 15 and 20 ml/l at different stages of the life cycle of the red mite of Paragua tea. They found that formulation (Azadirachtin @ 10, 15 and 20 ml/l) was efficient in controlling adults. Azadirachtin also affected the fecundity of the female mites. Rajaram *et al*. (2001*)* studied the effects of variations in levels of irrigation, nitrogen potassium on infestation by chilly mite. The various irrigation levels did not influence the mite population significantly. Plots without nitrogen supported the lowest mite population whereas potassium application reduced the mite population. Yield increased with nitrogen and potassium application.

4.2 Effect of different treatments on aphid

4.2.1 Number of aphids/plant

The application of botanicals and different chemical pesticides in controlling aphids showed statistically significant variation (Table 2 and appendix VI). The lowest number of aphid/per plant (41.89) was recorded from the treatment T_3 (Neem oil @ 15ml/l) which was closely followed by the treatment T_4 (Biskatali leaf extract @ 20g/l), T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) but significantly different from the treatment T_3. On the other hand, the highest number of aphids (163.40) were recorded from T_8 (untreated control) which was closely followed by the treatment T_2 (142.90) as the application of Neem seed extract @ 20g/l.

4.2.2 Percent (%) aphid/plant

The application of botanicals and different chemical pesticides in controlling aphids showed statistically significant variation (Table 2 and appendix VI).

The lowest percentage of aphid/plant (4.06%) was recorded from the treatment T_3 (Neem oil @ 15ml/l) which was closely followed by the treatment T_4, T_5 and T_7 but significantly different from T_3. On the other hand, the highest (26.09%) percentage was recorded from T_8 (untreated control) which was closely followed by the treatment T_1 and T_2. The treatment T_6 indicates that it was less effective to remove aphids. From the findings it was revealed that treatment T_3 performed better with maximum healthy leaves and minimum infestation as well as lowest % of aphid infestation by number whereas in control treatment the situation is reversed.

Table 2. Effects of botanicals and chemical pesticides on the incidence of aphids in chili

Treatments	Number of aphids/plant	Percent (%) aphids on leaves/plant
T_1	113.30 c	17.27 c
T_2	142.90 b	22.13 b
T_3	41.89 h	4.06 h
T_4	58.61 f	7.76 e
T_5	51.39 g	5.43 g
T_6	88.62 d	12.56 d
T_7	61.23 e	7.10 f
T_8	163.4 a	26.09 a
$LSD_{0.05}$	1.352	0.665
CV (%)	5.86	7.96

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

In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval

T_6 = Arozim@ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

Similar finding was obtained by Frantz *et. al*. (2004). They observed that botanicals were more effective than chemical insecticide. To control aphids they used chemicals (Cypermethrin, 250 g/ha) and botanicals (green neem leaf extract @ 1:15, dry neem leaf @ 1:40 and neem oil @ 1: 50) and they found that botanicals were more effective (60%, 70% and 75% respectively) than chemicals (55%).

4.3 Effect of different treatments on white fly

4.3.1 Number of white fly/plant

The experiment with the application of botanicals and different chemical pesticides in controlling white fly showed statistically significant variation by number (Table 3 and appendix VII). The lowest number of white fly/plant (4.73) was recorded from the treatment T_3 (Neem oil @ 15ml/l). On the other hand, the highest number (20.03) of white fly was recorded from T_8 (untreated control) which was statistically identical (18.30) with treatment T_2 (Neem seed extract @ 20g/l) and closely followed by T_1 (Neem leaf extract @ 20g/l). The results (on the no of white fly per plant) from the treatments T_4, T_5, T_6 and T_7 were ranged from 10.20 to 14.00. Among the different treatments neem oil removed white fly more effectively than the others.

4.3.2 Percent (%) white fly/plant

The experiment with the application of botanicals and different chemical pesticides in controlling white fly showed statistically significant variation by number (Table 3 and appendix VII). The lowest percentage of white fly/plant (0.46%) was recorded from the treatment T_3 (Neem oil @ 15ml/l) which was closely followed (1.07) by T_5 (Garlic clove extract @ 15ml/l). On the other hand, the highest (3.32%) percentage of leaf infestation was recorded from T_8 (untreated control) which was statistically identical (2.83) with T_2 (Neem seed extract @ 20g/l) and closely followed (2.66) by the treatment T_1 (Neem leaf extract @

20g/l) and the results from the treatments T_4, T_6 and T_7 indicate that Neem oil (T_3) was more effective to remove white fly. From the findings it was revealed that the treatment T_3 (Neem oil @ 15ml/l) performed in producing maximum healthy leaves in respect to white fly infestation and minimum infestation as well as lowest % of infestation by number whereas in control treatment the situation was opposite. Among the different treatments as a whole, Neem oil was more effective in controlling white fly than the others under the present study.

Weintraub *et. al*. (2003) found that neem leaf extract (2%), neem seed kernel (5%) and cold pressed neem oil reduced the white fly infestation on treated plants and inhibited eggs hatches, which was similar with present findings.

Table 3. Effects of botanicals and chemical pesticides on the incidence of white fly in chili

Treatments	Number of white fly/plant	Percent (%) infestation on leaves
T_1	17.47 ab	2.66 ab
T_2	18.30 a	2.83 a
T_3	4.73 d	0.46 e
T_4	14.00 b	1.85 c
T_5	10.20 c	1.07 de
T_6	14.00 b	1.98 bc
T_7	12.80 bc	1.48 cd
T_8	20.03 a	3.32 a
$LSD_{0.05}$	0.5312	0.722
CV (%)	8.18	6.70

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

In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

4.4 Effect of different treatments on fruit borer

4.4.1 Percent (%) fruit borer/plant

The application of botanicals and different chemical insecticides against different fruit borer of chili showed statistically significant variation for presence of infestation in percentage (Table 4 and Appendix VIII). The lowest percentage of fruit borer (3.88%) presence was recorded from the treatment T_3 (Neem oil @ 15ml/l) which was statistically identical (4.14%) with the treatment T_5 (Garlic clove extract @ 15ml/l) and similar result (4.79%) was obtained with T_7 (Thiolux @ 3g/l). On the other hand, the highest percentage (9.21%) in respect of fruit borer presence was recorded from T_8 (untreated control). The presence of fruit borer at higher percentage was recorded from the treatment T_1 (Neem leaf extract @ 20g/l) and T_2 (Neem seed extract @ 20g/l).

Table 4. Effects of botanicals and chemical pesticides on the incidence of fruit borer in chili

Treatments	Percent (%) fruit borer/plant
T_1	6.52 c
T_2	7.55 b
T_3	3.88 e
T_4	5.69 bc
T_5	4.14 e
T_6	5.36 d
T_7	4.79 de
T_8	9.21 a
$LSD_{0.05}$	0.636
CV (%)	8.33

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment.
In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval

T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

Kumar *et al.* (2001) revealed a similar finding. They studied that the bio-efficacy of selected insecticides against pest complex of chili and found that Imidacloprid (70 g/ha) was the most effective treatment in controlling aphids (99.76% reduction), Acephate (1500 g/ha) was the most effective treatment in controlling white fly and thrips (87.22% and 82.23% reduction) respectively. Cypermethrin (300 g/ha) was generally the most effective treatment against borers.

Harvant-Singh *et al.* (1999) studied the efficacies of neem, garlic, tagak-tagak compared with malathion on chili against aphids and fruit borer at different time intervals. Neem extract @ 5000 ppm generally recorded low aphid populations when compared with unsprayed control, malathion and other plant extracts, especially at 8 and 12 days after sparing. Neem extract also recorded an average fewer plants infected with virus symtoms when compared with other treatments.

4.5 Effect of different treatments on lady bird beetle

4.5.1 Number of lady bird beetle/plant

Significant variation on number of lady bird beetle/branch on leaves was found among the treatments during the experiment (Table 5 and Appendix IX). It was observed that the highest number of lady bird beetle (10.47) was observed in the treatment of T_8 (untreated control) and the lowest number (2.437) was in treatment T_3 (Neem oil @ 15ml/l). The treatments T_1, T_2, T_4 and T_6 showed higher presence of lady bird beetle and ranged from 7.00 – 9.17 but significantly different from T_8. Treatment T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed lower presence of lady bird beetle but significantly different from T_3.

4.5.2 Percent (%) lady bird beetle/plant

The application of botanicals and different chemical pesticides against pest complex of chili showed statistically significant variation for the percent (%) presence of lady bird beetle (Table 5 and Appendix IX) among the treatments. It was observed that the highest percentage of lady bird beetle (1.67%) according to the presence on leaves was in the treatment of T_1 (untreated control) and the lowest percentage of lady bird beetle (0.23%) was in treatment T_3 (Neem oil @ 15ml/l) which was not significantly different from T_5 (0.52%) as the application of Garlic clove extract @ 15ml/l and the treatments T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l) showed significantly similar result with T_3. The presence of lady bird beetle in percent was higher in T_1 (Neem leaf extract @ 20g/l) and T_2 (Neem seed extract @ 20g/l) but significantly different from T_8.

Table 5. Effects of botanicals and chemical pesticides on the incidence of natural enemies (Lady Bird Beetle) in chili

Treatments	Number of lady bird beetle/plant	Percent (%) lady bird beetle/plant
T_1	8.87 b	1.36 b
T_2	9.17 b	1.41 b
T_3	2.44 e	0.23 c
T_4	7.00 bc	0.93 bc
T_5	4.95 d	0.52 c
T_6	7.99 c	1.13 b
T_7	6.00 de	0.69 bc
T_8	10.47 a	1.67 a
$LSD_{0.05}$	0.907	0.246
CV (%)	7.67	9.44

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment.
In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

4.6 Effect of different treatments on spider

4.6.1 Number of spider/plant

Significant variation on number of spider/plant on leaves with the application of different chemical insecticides and botanicals against the natural enemies (spider) was found among the treatments (Table 6 and Appendix X). It was observed that presence of the highest number of spider (8.92) was in the treatment of T_8 (untreated control). Presence of the lowest number of spider (2.03) was in treatment T_3 (Neem oil @ 15ml/l). The treatments T_1, T_2, T_4 and T_6 showed higher presence of spider and ranged from 5.38 - 6.95 but significantly different from T_8. On the other hand, T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed lower incidence of spider and ranged from 4.00 – 4.84 but significantly different from T_3

4.6.2 Percent (%) spider/plant

Significant variation on the presence of spider/plant on leaves in percent with the application of botanicals and different chemical pesticides against the natural enemies (spider) was found among the treatments (Table 6 and Appendix X). It was observed that presence of the highest percentage of spider (1.42%) on leaves was in the treatment of T_8 (untreated control) which was not significantly different from T_1 (Neem leaf extract @ 20g/l) and T_2 (Neem seed extract @ 20g/l) and statistically similar with T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l). Presence of the lowest percentage of spider (0.19%) was in treatment T_3

(Neem oil @ 15ml/l) which was not significantly different from T_5 (0.42%) (Garlic clove extract @ 15ml/l) and statistically similar with T_7 (Thiolux @ 3g/l). It was observed that application of Neem oil showed the best performance for controlling spider than the other treatments.

Table 6. Effects of botanicals and chemical pesticides on the incidence of natural enemies (spider/plant) in chili

Treatments	Number of spider/plant	Percent (%) spider/plant
T_1	6.94 b	1.05 a
T_2	6.95 b	1.07 a
T_3	2.03 d	0.19 c
T_4	5.38 bc	0.71 ab
T_5	4.00 c	0.42 c
T_6	6.01 b	0.85 ab
T_7	4.84 c	0.56 bc
T_8	8.92 a	1.42 a
$LSD_{0.05}$	1.277	0.515
CV (%)	9.80	8.51

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment.
In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

4.7 Effect of different treatments on leaves against pest complex of chili

4.7.1 Number of total leaves/plant

Statistically significant variation was recorded in number of total leaves/plant (Table 7 and Appendix IV). The total number of leaves due to application of botanicals and different pesticides under the present trial, the highest number (1021.67) of leaves per plant was recorded from the treatment T_3. On the other

hand, the lowest number (626.71) of leaves/plant were recorded from T_8 treatment (untreated control) which was closely followed by the treatment T_1 (Neem leaf extract @ 20 g/l) and T_2 (Neem seed extract @ 20gm/l). Treatment T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux 3 g/l) showed higher number of leaves; 647.10 and 862.70 respectively but significantly different from T_3. On the other hand, treatment T_4 (Biskatali leaf extract @ 20 g/l) and T_6 (Aroslin @ 3g/l) showed lower number of leaves; 755.01 and 705.70 respectively but significantly different from T_8. The results were recorded from the different treatments on leaves/plant as a whole botanicals (Neem oil @ 15ml/l) was most effective than the others under the present study.

4.7.2 Number of healthy leaves

Application of botanicals and different chemical pesticides for the management of different insects on leaves of chili under the present trial showed a statistically significant difference in number of healthy leaves (Table 7 and Appendix IV). The healthy leaves of chili plot treated by chemical pesticides and botanicals are shown in plate 6. Highest number of healthy leaves (10011.62) per plant was recorded from the treatment T_3 (neem oil @ 15 ml/l). On the other hand, the lowest number (603.20) of healthy leaves was recorded from T_8 (untreated control) which was statistically identical with the treatment T_1 (neem leaf extract @ 20 g/l) and T_2 (neem seed extract@ 20 g/l). Similarly, from treatment T_4, T_5, T_6 and T_7, healthy leaves were recorded in intermediate level for these as compare with untreated control (738.92, 935.19, 690.25 and 852.21 respectively).

A

B

Plate 6.

A. Chemical pesticides treated chili plot
B. Botanicals treated chili plants

4.7.3 Number of infested leaves

Statistically significant variation by number of infested leaves presented in Table 7 and Appendix IV. The infested chili leaves and twigs are shown in plate 7. The lowest number of infested leaves (9.05) were recorded from the treatment T_3 (Neem oil @ 15ml/l) which was statistically identical with the treatment T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l). On the other hand, the highest number (23.51) of infested leaves were recorded from T_8 (untreated

control) which was statistically similar with the treatment T_2 (Neem seed extract @ 20g/l). From treatment T_1, T_4 and T_6 infested leaves were recorded in intermediate level for these as compare with untreated control (15.43, 13.10 and 15.55, respectively).

A B

Plate 7.
A. Infested chili leave,
B. Infested chili twig

4.7.4 Percent (%) infestation

Statistically significant variation of infestation percentage of infested leaves was presented in Table 7 and Appendix IV. The lowest percentage of leaves infestation (0.88%) was recorded from the treatment T_3 (Neem oil @ 15ml/l) which was statistically identical (0.99%) with the treatment T_5 (Garlic clove extract @ 15ml/l). On the other hand, the highest percentage of leaves infestation

(3.78%) was recorded from T_8 (untreated control) which was statistically identical (3.24%) with the treatment T_2 (Neem seed extract @ 20g/l) which was followed by T_1 (Neem leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l). From treatment T_4 and $T_{7,}$ percent infestation was recorded in intermediate level for these as compared to untreated control (1.74 and 1.22 respectively).

4.7.5 Percent (%) Reduction over control

In terms of leaves infestation reduction over control in number was estimated where the highest value (76.50%) was recorded from the treatment T_3 (Neem oil @ 15ml/l) which was statistically identical with treatment T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) and the values were 73.59% and 67.60% respectively. The lowest (14.30%) reduction of leaves infestation over control was in treatment T_2 (Neem seed extract @ 20g/l). T_4 (Biskatali leaf extract @ 20g/l) showed higher infestation reduction over control, T_1 (Neem leaf extract @ 20g/l) and T_6 (Arozim @ 3g/l) showed intermediate level of infestation reduction over control (54.00%, 37.86% and 41.69% respectively).

Table 7. Effects of botanicals and chemical pesticides against pest complex of chili during total cropping season by number/plant

Treatments	Number of total leaves	Number of healthy leaves	Number of Infested leaves	Percent (%) Infestation of leaves	Percent (%) Reduction over control
T_1	655.70 f	603.20 f	15.43 b	2.35 ab	37.86 c
T_2	645.67 f	624.70 f	20.93 ab	3.24 a	14.30 d
T_3	1021. 67 a	1011.62 a	9.05 c	0.88 c	76.50 a
T_4	755.01 d	738.92 d	13.10 bc	1.74 b	54.00 b
T_5	947.10 b	935.19 b	9.49 c	0.99 c	73.59 a
T_6	705.70 e	690.25 e	15.55 b	2.20 ab	41.69 c
T_7	862.70 c	852.21 c	10.49 c	1.22 bc	67.60 a
T_8	640.23 f	626.71 f	23.67 a	3.78 a	--
$LSD_{0.05}$	36.86	37.67	3.466	0.961	7.724
CV(%)	6.71	6.82	7.81	5.57	8.86

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment.
In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

4.8 Effect of treatments on fruits against pest complex of chili

4.8.1 Number of fruits/plant

The application of botanicals and different chemical pesticides against different insects on fruits of chili showed statistically significant variation in number of fruits/branch (Table 8 and Appendix XI). The highest number of fruits (41.20)

was recorded from T_3 (neem oil @ 15ml/l) which was not statistically different (41.00) from the treatment T_5 (garlic clove extract @ 15ml/l). T_7 (Thiolux @ 3g/l) also gave the higher result (39.60) but not similar with T_3 and T_5. On the other hand, the lowest number of fruits (30.40) was recorded from the treatment T_8 (untreated control). T_1 (neem leaf extract @ 20g/l) and T_2 (neem seed extract @ 20g/l) also gave lower result but not similar with T_8. From treatment T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l), number of fruits was recorded in intermediate level for these as compare with untreated control treatment.

A

B

Plate 8.

A. Healthy green chili fruit

B. Healthy ripen chili fruit

4.8.2 Number of healthy fruits

Significant variation was observed for number of healthy fruits with the application of botanicals and different chemical insecticides against pest complex of chili (Table 8 and Appendix XI). The healthy green and ripen fruits treated by chemicals and botanicals are shown in plate 8. The highest number of healthy fruits (38.00) was observed in the treatment T_3 (Neem oil @ 15ml/l) which was statistically identical (37.60) with T_5 (Garlic clove extract @ 15ml/l) and closely followed (35.60) by T_7 (Thiolux @ 3g/l). The lowest number of healthy fruits (22.13) was observed in T_8 (untreated control).

4.8.3 Number of infested fruit

Significant variation was observed for number of infested fruits with the application of botanicals and different chemical pesticides against pest complex of chili (Table 8 and Appendix XI). Chili fruit borer and infested fruits are shown in plate 9. The highest number of infested fruits (8.27) was observed from the treatment T_8 (untreated control) and the lowest number of infested fruits (3.20) was observed from the treatment T_3 (Neem oil @ 15ml/l) which was similar to T_5 (Garlic clove extract @ 15ml/l). It was also observed that T_4, T_6 and T_7 showed lower infestation but significantly different from T_3 and T_1 and T_2 (Neem seed extract @ 20g/l) gave higher infestation but significantly different from T_8.

A

B

Plate 9.

A. Larva of chili fruit borer on chili
B. Infested chili fruit

4.8.4 Percent (%) infestation

The application of botanicals and different chemical pesticides against pest complex of chili showed statistically significant variation for the percent (%) infestation of fruits with fruit borer (Table 8 and Appendix XI). It was observed that the highest percentage of fruit infestation (27.20%) was observed in the treatment T_8 (untreated control) and the lowest percentage of infestation (7.76) was observed in the treatment T_3 (Neem oil @ 15ml/l). It was also observed that T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed lower percent infestation but significantly different from T_3. The results from the treatments T_1, T_2, T_4 and T_6 were ranged from 11.39% to 15.69%. Among the different treatments, application of neem oil was considered as best against percent infestation of fruit with fruit borer.

4.8.5 Percent (%) Reduction over control

Reduction over control was significantly different among the treatments with the application of botanicals and different chemical pesticides against pest complex of chili (Table 8 and Appendix XI). It was observed that the highest percentage of reduction over control (71.46%) was observed in the treatment T_3 (Neem oil @ 15ml/l) and the lowest percentage of reduction over control (42.30%) was observed in the treatment T_1 (Neem leaf extract @ 20g/l) which was statistically identical with T_2 (Neem seed extract @ 20g/l) was 42.30%. It was also observed that T_5 (garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed higher percentage of reduction over control but significantly different from T_3. The results from the treatments, T_4 and T_6 (58.11% and 53.81 respectively) showed lower percentage of reduction over control but significantly different from T_1.

From the findings it is revealed that treatment T_3 performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in number

whereas in control treatment the situation was reversed (Plate 1). Kulat *et al.* (2001); Prabal *et al.* (2000) reported from their experiment on extracts of some indigenous plant materials, which are claimed important as pest control like seed kernels of neem. Weekly spray application of the extract of neem seed kernel has been found to be effective against borer (Karim, 1994).

Table 8. Effects of botanicals and chemical pesticides against chili fruit borer by number per plant in total cropping season

Treatments	Number of total fruits	Number of healthy fruits	Number of infested fruit	Percent (%) infestation	Reduction over control (%)
T_1	36.80 e	31.13 c	5.67 b	15.39 b	43.42 f
T_2	34.40 f	29.13 d	5.40 bc	15.69 b	42.30 f
T_3	41.20 a	38.00 a	3.20 e	7.76 g	71.46 a
T_4	38.60 c	34.20 b	4.40 cd	11.39 d	58.11 d
T_5	41.00 a	37.60 a	3.40 e	8.29 f	69.53 b
T_6	38.20 d	33.47 bc	4.80 c	12.56 c	53.81 e
T_7	39.60 b	35.60 ab	4.00 d	10.10 e	62.87 c
T_8	30.40 g	22.13 e	8.27 a	27.20 a	--
$LSD_{0.05}$	0.248	1.192	0.366	0.372	1.792
CV(%)	6.38	5.33	7.99	8.56	6.78

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment.
In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

4.9 Comparative effectiveness of different treatments on leaves of chili

4.9.1 Percent (%) red mite per plant

Percentage of total red mites on leaves was found significant with the application of botanicals and different chemical pesticides against pest complex of chili among the treatments during the experiment (Figure 1 and Appendix XII). It was observed that presence of the highest percentage of red mites (62.33%) on leaves was in the treatment of T_8 (untreated control) and presence of the lowest percentage of red mites (24.30%) was in treatment T_3 (Neem oil @ 15ml/l). Treatments T_1, T_2, T_4 and T_6 showed presence of higher percentage of red mites and ranged from 40.07% - 56.66% but significantly different from T_8. On the other hand, T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed presence of lower percentage of red mites 29.99% and 33.99% respectively but significantly different from T_3.

4.9.2 Percent (%) aphid per plant

Percentage of total aphid on leaves was found significant with the application of botanicals and different chemical pesticides against pest complex of chili among the treatments during the experiment (Figure 1 and Appendix XII). It was observed that presence of the highest percentage of aphid (26.09%) on leaves was in the treatment of T_8 (untreated control) and presence of the lowest percentage of aphid (4.06%) was in treatment T_3 (Neem oil @ 15ml/l). Treatment T_1 (Neem leaf extract @ 20g/l), T_2 (Neem seed extract @ 20g/l) and T_6 (Aroslin @3g/l) showed presence of higher percentage of aphid and ranged from 12.23% - 22.13% but significantly different from T_8. On the other hand, T_4 (Biskatali leaf extract @ 20g/l), T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed presence of lower percentage of aphids and ranged from 5.43% - 7.76% but significantly different from T_3.

4.9.3 Percent (%) white fly per plant

Percentage of total white fly on leaves was found Significant with the application of botanicals and different chemical pesticides against pest complex of chili among the treatments during the experiment (Figure 1 and Appendix XII). It was

observed that presence of the highest percentage of white fly (3.32%) on leaves was in the treatment of T_8 (untreated control) which was significantly similar with T_1 (Neem leaf extract @ 20g/l) and T_2 (Neem seed extract @ 20g/l). Presence of higher percentage of white fly was also shown in T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l) but significantly different from T_8. On the other hand, the lowest percent of white fly (0.46%) was in treatment T_3 (neem oil @ 15ml/l) and T_5 (garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed lower percentage of white fly but significantly different from T_3.

4.10 Comparative effectiveness of different treatments on fruits

4.10.1 Percent (%) fruit borer per plant

Presence of total fruit borer in percentage on fruits was found Significant with the application of botanicals and different chemical pesticides against pest complex of chili among the treatments during the experiment (Figure 1 and Appendix XII). It was observed that presence of the highest percentage of fruit borer (9.21%) on fruits was in the treatment of T_8 (untreated control) which was not significantly different with T_2 (Neem seed extract @ 20g/l). Presence of higher percentage of fruit borer was also shown in T_1 (Neem leaf extract @ 20g/l), T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l) and ranged from 5.36% - 6.52% but significantly different from T_8. On the other hand, the lowest percent of fruit borer (3.88%) was in treatment T_3 (Neem oil @ 15ml/l) and T_5 (Garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed lower percentage of fruit borer 4.14% and 4.79% respectively but significantly different from T_3.

Simkin *et. al*. (2003) evaluated the variation of yield effectiveness at different growth stages and fruiting stages on the attack of insect and pests respectively. They observed that attack of pest on growth stages was more harmful for effective yield. They also observed that population number was decreased remarkably where the pest attack of growth stage was more than the attack of fruiting stage of plant.

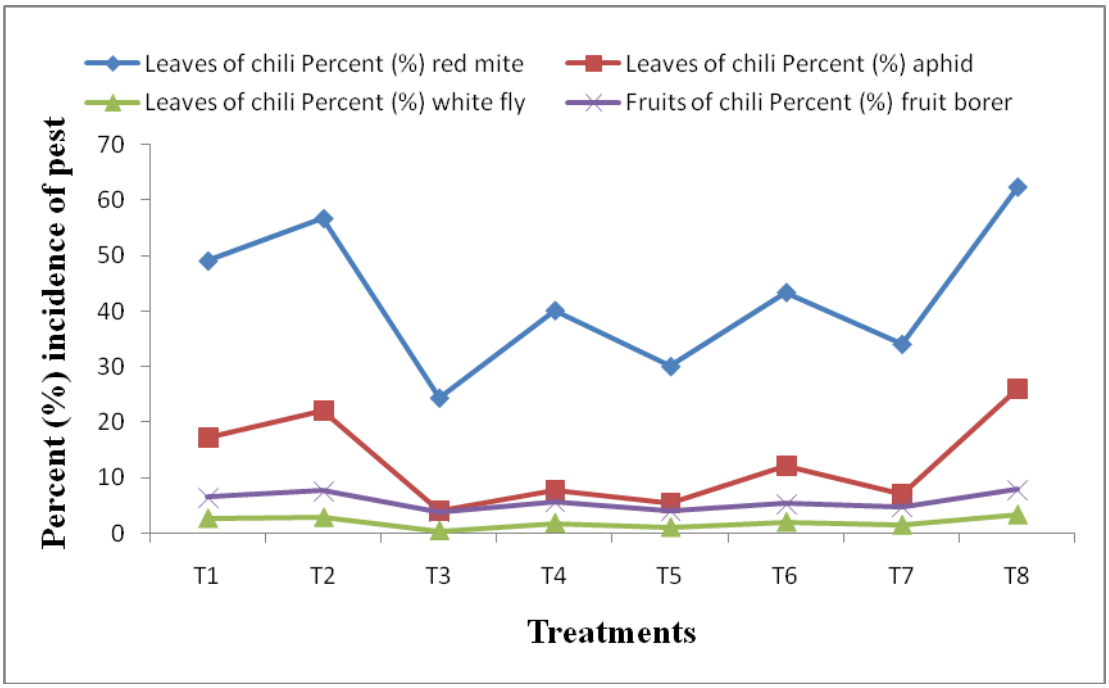


Figure 1. Comparative effect of botanicals and chemical pesticides on the incidence of pest complex of chili in percentage

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

4.11 Effect of treatments on yield against pest complex of chili

4.11.1 Weight of total fruits/plant (g)

Significant variation was observed incase of total fruit weight/plant (g) with the application of botanicals and different chemical pesticides and botanicals against

pest complex of chili during the experiment (Table 9 and Appendix XIII). The highest total fruit weight/plant (283.10 g) was obtained from T_3 (Neem oil @ 15ml/l) which was significantly similar (260.33 g) with T_5 (garlic clove extract @ 15ml/l). On the other hand, the lowest value total fruit weight/plant (252.90 g) was obtained from T_8 (untreated control). Treatment T_4, T_6 and T_7 showed higher value of total fruit weight/plant and ranged from 275.44 g - 279.29 g but significantly different from T_3. Treatment T_1 (neem leaf extract @ 20g/l) and T_2 (neem seed extract @ 20g/l) showed lower value of total fruit weight/plant compared to the highest value of total fruit weight.

4.11.2 Weight of healthy fruits/plant (g)

Weight of healthy fruits/plant (g) obtained from the different treatment with the application of botanicals and different chemical pesticides against pest complex of chilli during the experiment (Table 9 and Appendix XIII) were significantly different. The highest value of healthy fruit weight/plant (261.09 g) was obtained from T_3 (neem oil @ 15ml/l) which was significantly same with T_5 (garlic clove extract @ 15ml/l). On the other hand, the lowest value of healthy fruit weight/plant (203.71 g) was obtained from T_8 (untreated control). Treatments T_4 (Biskatali leaf extract @ 20g/l), T_6 (Aroslin @ 3g/l) and T_7 (Thiolux @ 3g/l) showed higher value of healthy fruits weight and ranged from 242.19 g - 251.20 g but significantly different from T_3. Treatment T_1 (neem leaf extract @ 20g/l) and T_2 (neem seed extract @ 20g/l) showed lower value of healthy fruit weight/plant compared to highest value of healthy fruit weight.

4.11.3 Weight of infested fruit/plant (g)

Weight of infested fruit/plant (g) obtained from the different treatments with the application of botanicals and different chemical pesticides against pest complex of chili during the experiment (Table 9 and Appendix XIII) were significantly different. The highest value of infested fruits weight/plant (50.19 g) was obtained from T_8 (untreated control) and the treatments, T_1 (neem leaf extract @ 20g/l) and T_2 (neem seed extract @ 20g/l) showed higher value of infested fruit weight/plant

but significantly different from T_8. On the other hand, the lowest value of infested fruits weight/plant (23.01 g) was obtained from T_3 (neem oil @ 15ml/l) which was significantly same with T_5 (garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed lower infested fruit weight compared to the lowest infested fruit weight.

Treatment T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l) showed intermediate result of infested fruit weight compared to the highest and lowest value.

4.11.4 Percent (%) infestation of fruits

Percent infestation in fruits of chili obtained from the different treatment with the application of botanicals and different chemical pesticides against pest complex of chili during the experiment (Table 9 and Appendix XIII) was significantly different. The highest value of percent infestation (19.84%) was observed from T_8 (untreated control) and the treatments, T_1 (neem leaf extract @ 15ml/l) and T_2 (neem seed extract @ 20g/l) showed higher percent of infested fruit weight 13.77% and 15.36% respectively but significantly different from T_8. On the other hand, the lowest percent of infested fruits weight (8.12%) was obtained from T_3 (neem oil @ 15ml/l) which was significantly same with T_5 (garlic clove extract @ 15ml/l) whereas the value was 8.48% and T_7 (Thiolux @ 3g/l) showed lower percent of infested fruit weight (10.41%) compared to the lowest percent of infested fruit weight and T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l) showed intermediate result of percent infested fruit weight compared to the highest and lowest value.

4.11.5 Percent (%) Reduction over control

The results obtained from the different treatments, the significant variation was observed in terms of reduction over control (Table 9 and Appendix XIII). The highest (59.06%) and lowest (30.59%) reduction over control was shown in treatment T_3 (neem oil @ 15ml/l) and T_1 (neem leaf extract @ 20g/l) respectively. T_5 (garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l) showed

higher reduction over control 57.26% and 47.53% respectively but significantly different from T_3. Treatment T_2 (neem seed extract @ 20g/l), T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l) showed lower reduction over control and ranged from 22.56% - 40.63% but significantly different from T_1.

Table 9. Effects of botanicals and chemical pesticides against chili fruit borer in weight per plant during total cropping season

Treatments	Weight of total fruits (g)	Weight of healthy fruits (g)	Weight of infested fruit (g)	Percent (%) infestation	Reduction over control (%)
T_1	270.01 d	233.81 d	37.20 c	13.77 bc	30.59 f
T_2	268.55 d	228.28 e	41.27 b	15.36 b	22.56 g
T_3	283.10 a	261.09 a	23.01 f	8.12 f	59.06 a
T_4	277.86 bc	246.11 c	32.75 d	11.78 cd	40.63 d
T_5	280.33 ab	257.60 a	23.79 f	8.48 ef	57.26 b
T_6	275.44 c	242.19 c	34.25 cd	12.43 cd	37.35 e
T_7	279.29 b	251.20 b	29.09 e	10.41 de	47.53 c
T_8	252.90 e	203.71 f	50.19 a	19.84 a	--
$LSD_{0.05}$	3.498	4.680	3.096	2.161	0.4247
CV (%)	7.73	8.11	5.21	9.85	7.57

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment.
In a column means followed by the same alphabet do not differ significantly by DMRT (0.05) and the dissimilar alphabet differ significantly by the same test.

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

4.12 Yield performance

4.12.1 Yield (kg/plot)

Significant variation was recorded for plot yield of chili for the application of botanicals and different chemical pesticides on yield of chili during total cropping season against pest complex of chili (Figure 2 and Appendix XIV). The highest fruit weight (13.60 kg) was obtained from T_3 (neem oil @ 15ml/l) which was statistically identical (11.58 kg) with the treatment T_5 (garlic clove extract @ 15ml/l) and was closely followed by T_7 (10.95 kg) (Thiolux @ 3g/l). On the other hand the lowest yield of fruit (7.59 kg) was recorded from T_8 (untreated control) which was closely followed by T_1 (neem leaf extract @ 20g/l), T_2 (neem seed extract @ 20g/l), T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l). Among the different treatments, application of neem oil was considered as best fruit yield (kg/plot) against pest complex of chili.

4.12.2 Yield (t/ha)

Yield per hectare varied statistically for the application of botanicals and different chemical pesticides on yield of chili during total cropping season against pest complex of chili (Figure 2 and Appendix XIV). Highest weight of fruit yield (30.22 t/ha) was recorded from the treatment T_3 (neem oil @ 15ml/l) which was statistically similar (25.73 t/ha) with the treatment T_5 (garlic clove extract @ 15ml/l). On the other hand, the lowest yield (16.87 t/ha) of fruit was recorded from T_8 (untreated control) which was statistically identical (18.04 t/ha) with the treatment T_2 (neem seed extract @ 20g/l) and was closely followed by T_1 (neem leaf extract @ 20g/l), T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l). Treatment T_7 (Thiolux @ 3g/l) showed higher weight of fruit yield (24.33 t/ha) which was statistically similar with T_5 but significantly different from T_3. Among different treatments, application of neem oil was considered as best fruit yield (t/ha) against pest complex of chili.

4.12.3 Percent (%) Increase over control

Increase over control with the application of different botanicals and chemical pesticides (Figure 2 and Appendix XIV) varied statistically and was estimated the highest value (79.18%) from the treatment T_3 (Neem oil @ 15ml/l), while the

lowest value was (6.97%) from the treatment T_2 (Neem seed extract @ 20g/l) on yield of chili during total cropping season against pest complex of chili.

Similar finding was obtained by Materska *et. al.* (2006) and they stated that among the different chemicals (imidacloprid, chlorfenapyr, abamectin, cyfluthrin and methiocarb) and plant extract; neem oil (*Azadirachtin*), karanja oil (*Pongamia glubra*)**,** Mahua oil (*Madhuca lalifolia*) for pipper yield, neem oil was the best protector compared to other botanicals and chemicals in respect of biological yield.

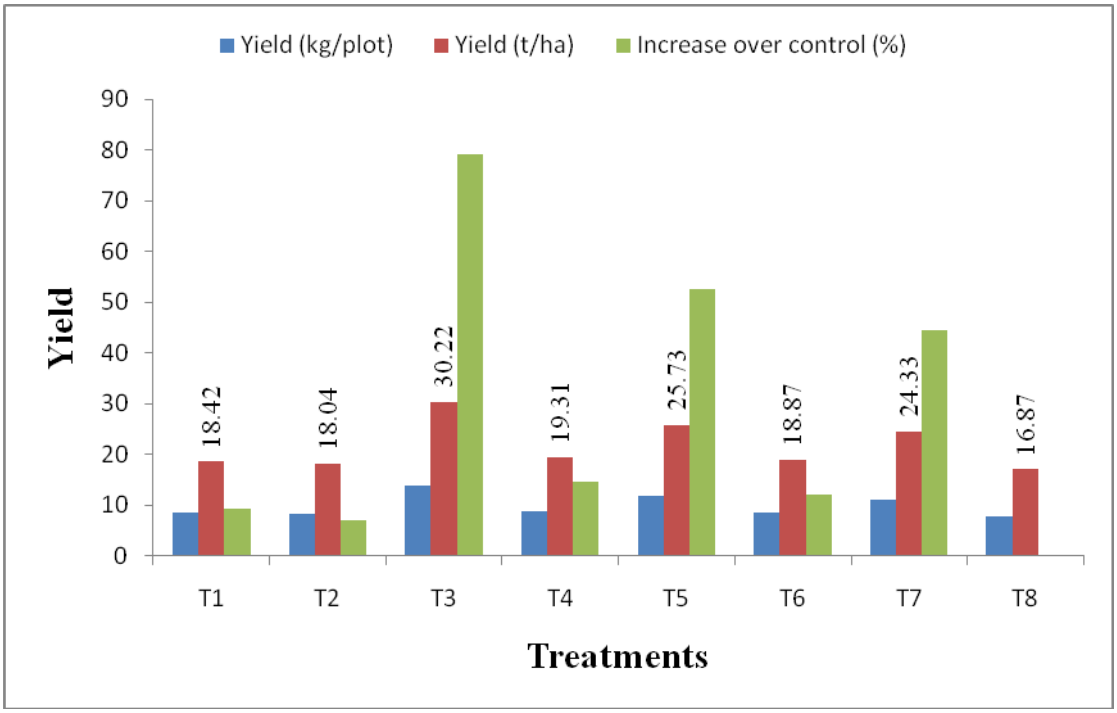


Figure 2. Effects of botanicals and chemical pesticides on yield of chili during total cropping season

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim @ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

4.13 Economic analysis

Economic analysis was classified in terms of total cost of production, gross return, net return and Benefit Cost Ratio (BCR) and cost of different chemical pesticides, botanicals and related or recommended other cost were calculated and presented in Table 10 and Appendix XV. In this study, the untreated control did not require any pest management cost. For botanical extract labor cost also involved with the product value. In the chemical treated plot cost of chemicals and labor for the application were included for the total cost.

4.13.1 Total cost of production (Tk. /ha)

Total cost of production varied statistically for the application of botanicals and different chemical pesticides on yield of chili during total cropping season against pest complex of chili (Table 10 and Appendix XV). Highest cost of production (203750.00 Tk. /ha) was recorded from the treatment T_3 (neem oil @ 15ml/l). On the other hand, the lowest cost of production (199960.00 Tk./ha) was recorded from T_4 (Biskatali leaf extract @ 20g/l) where T_8 (untreated control) required 197930.00 Tk./ha. The cost of production from the Treatment, T_2 (neem seed extract @ 20g/l) and T_5 (garlic clove extract @ 15ml/l); 201080.00 and 202800.00 Tk./ha respectively showed higher cost of production and T_1 (neem leaf extract @ 20g/l); 200060.00 Tk./ha showed lower cost of production but significantly different from T_3. The cost of production from the rest of the treatment was recorded as intermediate level. Among different treatments, neem oil treated crop was evaluated as the highest cost of production during the total cropping season of chili.

4.13.2 Gross return (Tk. /ha)

Significant variation was observed in case of gross return for the application of botanicals and different chemical pesticides on yield of chili during total cropping season against pest complex of chili (Table 10 and Appendix XV). The highest gross return (604400.00 Tk. /ha) was recorded from the treatment T_3 (neem oil @ 15ml/l) and the second highest gross return (514500.00 Tk./ha) was recorded from

the treatment T_5 (garlic clove extract @ 15ml/l). On the other hand, the lowest gross return (360800.00 Tk./ha) was recorded from T_2 (neem seed extract @ 20g/l) where T_8 (untreated control) required 337400.00 Tk./ha. It was observed that among the different treatments, neem oil treated crop was evaluated as the highest gross return during the total cropping season of chili.

4.13.3 Net return (Tk. /ha)

Significant variation was observed in case of net return for the application of botanicals and different chemical pesticides on yield of chili during total cropping season against pest complex of chili (Table 10 and Appendix XV). The highest net return (401600 Tk. /ha) was recorded from the treatment T_3 (neem oil @ 15ml/l) and the second highest net return (310850.00 Tk. /ha) was recorded from the treatment T_5 (garlic clove extract @ 15ml/l). On the other hand, the lowest net return (159720.00 Tk. /ha) was recorded from T_2 (neem seed extract @ 20g/l) where T_8 (untreated control) requisite 139470.00 Tk. /ha. It was observed that among the different treatments, neem oil treated crop was evaluated as the highest net return during the total cropping season of chili.

4.13.4 Benefit Cost Ratio (BCR)

Considering the controlling of pest complex of chili, the highest benefit cost ratio (2.97) was recorded in the treatment T_3 as Neem oil @ 15ml/l and next highest BCR was 2.54 found in T_5 (Garlic clove extract @ 15ml/l). On the other hand, the minimum cost benefit ratio (1.79) was recorded in treatment T_2 as Neem seed extract @ 20g/l where untreated control T_8 presented the lowest BCR (1.70) among the treatment (Table 10 and Appendix XV).

From the above findings it was found that commercially produced neem oil was the best pest management practice against pest complex of chili and also gave the highest BCR. On the other hand, the botanicals which were used in this study were more effective between chemical pesticides and botanicals in controlling pest complex of chili. So, it might be concluded that neem oil was the best application for controlling pest of chili compared to others.

Table 10. Effects of botanicals and chemical pesticides on economic analysis of chili production during total cropping Season

Treatments	Total cost of production (Tk./ha)	Gross return (Tk./ha)	Net return (Tk./ha)	BCR
T_1	200060.00 f	368400.00 f	168340.00 f	1.84 c
T_2	201080.00 c	360800.00 g	159720.00 g	1.79 c
T_3	203750.00 a	604400.00 a	401600.00 a	2.97 a
T_4	199960.00 g	386200.00 d	186240.00 d	1.93 c
T_5	202800.00 b	514500.00 b	310850.00 b	2.54 ab
T_6	200710.00 d	377400.00 e	176690.00 e	1.88 c
T_7	200990.00 e	486500.00 c	285610.00 c	2.42 b
T_8	197930.00 h	337400.00 h	139470.00 h	1.70 c
$LSD_{0.05}$	89.36	629.20	111.3	0.467
CV (%)	8.08	9.03	7.03	8.19

* Rate of different input and output cost per hectare are shown in appendix XVI

T_1 = Neem leaf extract @ 20 g/l at 3 days interval
T_2 = Neem seed extract @ 20 g/l at 3 days interval
T_3 = Neem oil @ 15 ml/l at 3 days interval
T_4 = Biskatali leaf extract @ 20 g/l at 3 days interval
T_5 = Garlic clove extract @ 15 ml/l at 3 days interval
T_6 = Arozim@ 3 g/l at 7 days interval
T_7 = Thiolux @ 3 g/l at 7 days interval
T_8 = Control

CHAPTER 5
SUMMARY AND CONCLUSION

The study was carried out in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from January to September 2008 to study on the efficacy of selected pesticides and botanicals on pest complex of chili (*Capsicum frutescens*). The experiment comprised with eight treatments and the treatments were T_1: Neem leaf extract @ 20 g/l at 3 days interval; T_2: Neem seed extract @ 20 g/l at 3 days interval; T_3: Neem oil @ 15 ml/l at 3 days interval; T_4: Biskatali leaf extract @ 20 g/l at 3 days interval; T_5: Garlic clove extract @ 15 ml/l at 3 days interval; T_6: Arozim @ 3 g/l at 7 days interval; T_7: Thiolux @ 3 g/l at 7 days interval and T_8: untreated control. The experiment was laid out at Randomized Complete Block Design (RCBD) with three replications. Data were recorded on healthy and infested leaves and fruits at different stage and yield of chili.

During the experiment, leaves, fruits, yield and yield contributing characters of chili were significantly influenced with the application of different botanicals and chemical pesticides on pest complex of chili. It was observed that the highest number of healthy leaves/plant (1011.62), the lowest number of infested leaves (9.05) and the lowest percent infestation (0.88%) were observed from T_3 treatment. On the other hand, the lowest number of healthy leaves/plant (640.23), the highest number of infested leaves (23.67) and the highest percent infestation (3.78%) were observed with the treatment T_8 (untreated control).

It was also observed that the presence (by number) of red mites/plant (248.21), aphids/plant (41.89), white fly/plant (4.73) on leaves were least with the treatment T_3 (neem oil @ 15ml/l) and highest (392.50, 163.40, 20.03) respectively, at T_8 (untreated control). The reduction over control among the different treatments was observed at the highest (76.50%) from T_3 (neem oil @ 15ml/l) and the lowest (14.30%) from T_2 (neem seed extract @ 20g/l).

Effect of the pest complex of chili on fruits with the infestation of fruit borer was significantly different among the treatments. It was observed that the highest number of healthy fruit/plant (38.00) was recorded from the treatment T_3 (neem oil @ 15ml/l) which was statistically identical (37.60) with T_5 (garlic clove extract @ 15ml/l) and closely followed (35.60) by T_7 (Thiolux @ 3g/l). On the other hand, the lowest (22.13) number of healthy fruit/plant was recorded from untreated control treatment (T_8) significant variation was observed with the application of different botanicals and chemical pesticides against pest complex of chili. The lowest number of infested fruit/plant (3.20) was recorded from the treatment T_3 (neem oil @ 15ml/l). On the other hand, the highest (8.27) number of infested fruit was recorded from untreated control (T_8). The lowest percentage of fruit infestation in number (7.76%) was recorded from the treatment T_3 (neem oil @ 15ml/l) and the highest (27.20%) was recorded from untreated control (T_8). Fruit infestation reduction over control by number was estimated the highest value (71.46%) was recorded from the treatment T_3 (neem oil @ 15ml/l), while the lowest was recorded from T_1 (neem leaf extract @ 20g/l) and T_2 (neem seed extract @ 20g/l) treatment (43.42% and 42.30% respectively).

In the cropping season the highest weight of healthy fruit/plant (261.09 g) was recorded from the treatment T_3 (neem oil @ 15ml/l) which was statistically identical (257.60 g) with the treatment T_5 (garlic clove extract @ 15ml/l). On the other hand, the lowest (203.71 g) weight of healthy fruit was recorded from untreated control (T_8). The lowest weight of infested fruit/plant (23.01 g) was recorded from the treatment T_3 (neem oil @ 15ml/l) which was statistically identical (23.79 g) with the treatment T_5 (garlic clove extract @ 15ml/l). On the other hand, the highest (50.19 g) weight of infested fruit was recorded from untreated control (T_8). The lowest percentage of fruit infestation in weight (8.12%) was recorded from the treatment T_3 which was statistically similar (8.48%) with the treatment T_5 (garlic clove extract @ 15ml/l). On the other hand, the highest (19.84%) fruit infestation was recorded from untreated control (T_8). Fruit infestation reduction over control in weight was estimated the highest value

(59.06%) was recorded from the treatment T_3 (neem oil @ 15ml/l), while the lowest (22.56%) reduction of fruit infestation over control was in T_2 (neem seed extract @ 20g/l) treatment.

The highest weight of fruit yield (30.22 t/ha) was recorded from the treatment T_3 (neem oil @ 15ml/l) which was statistically similar (25.73 and 24.33 t/ha) with the treatment T_5 (garlic clove extract @ 15ml/l) and T_7 (Thiolux @ 3g/l), respectively. On the other hand, the lowest yield (16.87 t/ha) of fruit was recorded from untreated control (T_8) which was statistically identical (18.04 ton/hectare) with T_2 (neem seed extract @ 20g/l) and closely followed by the treatment T_1 (neem leaf extract @ 20g/l), T_4 (Biskatali leaf extract @ 20g/l) and T_6 (Aroslin @ 3g/l); 18.42, 19.31 and 18.87 ton/hectare, respectively. Yield increase over control in weight was estimated the highest value (79.18%) from the treatment T_3 (neem oil @ 15ml/l), while the lowest (6.97%) increase of yield over control was in T_2 (neem seed extract @ 20g/l) treatment.

Among the different treatments as a whole, botanicals were more effective than the chemical pesticides. Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Further study may be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
2. Botanical extract with different concentration may be included in the future study.
3. New chemical pesticide may be included in the future study.
4. Sole Chemical pesticides and botanicals may be used.

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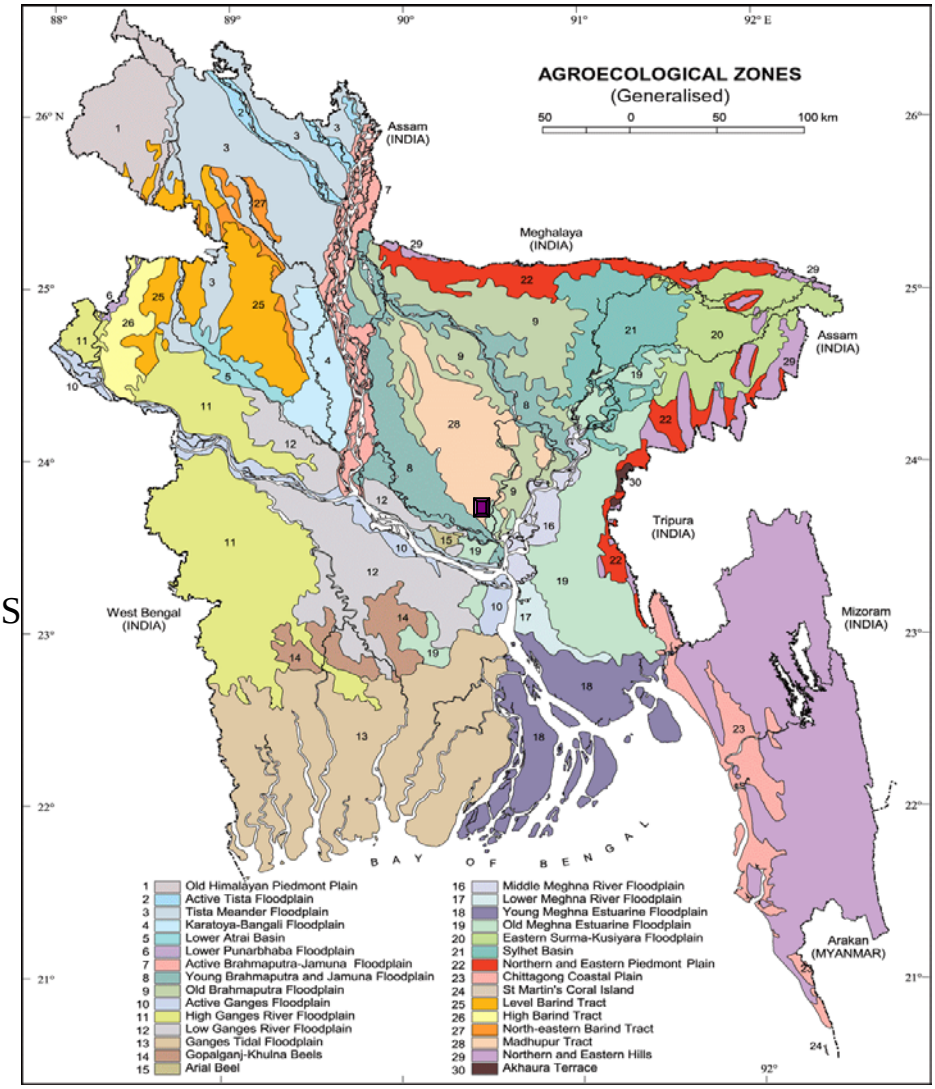
APPENDICES

Appendix I. Map showing the experimental site under the study



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Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from January 2008 to September 2008

Month	Year	Monthly average air temperature (^{0}C)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum	Mean			
January	2008	24.31	13.65	18.978	72.90	159	1455.00
February	2008	25.92	14.11	20.015	62.78	170	1827.50
March	2008	31.59	22.15	26.867	59.13	258	1821.00
April	2008	34.37	26.06	30.218	61.51	180	2546.00
May	2008	34.78	24.57	29.675	64.23	616	2359.00
June	2008	35.40	28.50	31.95	68.14	446	1246.00
July	2008	34.00	29.30	31.65	63.28	476	949.00
August	2008	36.00	29.50	32.75	69.11	318	1307.00
September	2008	34.80	30.80	32.80	70.00	288	1302.00

Source: Bangladesh Meteorological Department, Agargaon, Dhaka

Appendix III. Physical characteristics and chemical composition of soil of the experimental plot.

Soil Characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: SRDI, Dhaka

Appendix IV. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square				
		Number of total leaves/plant	Number of healthy leaves/plant	Number of Infested leaves/plant	Percent infestation	Reduction over control (%)
Replication	2	18.83	74.19	0.05	0.16	4.25
Treatment	7	66.73*	70.68*	85.68**	3.32**	5.32*
Error	14	3.02	4.73	2.071	1.003	1.939

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

Appendix V. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square	
		Number of red mites/plant	Percent (%) red mites/plant
Replication	2	24.63	3.16
Treatment	7	63.95*	52.95*
Error	14	2.792	1.035

Appendix VI. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square	
		Number of aphids/plant	Percent (%) aphids on leaves/plant
Replication	2	0.08	0.18
Treatment	7	20.45**	39.67**
Error	14	1.144	1.020

Appendix VII. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square	
		Number of white fly/plant	Percent (%) white fly on leaves/plant
Replication	2	0.245	0.032
Treatment	7	72.27**	2.73**
Error	14	2.092	1.017

** Significant at 0.01 level of probability

* Significant at 0.05 level of probability

Appendix VIII. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square	
		Number of fruit borer/plant	Percent (%) fruit borer on leaves/plant
Replication	2	0.070	0.442
Treatment	7	0.543**	9.779**
Error	14	0.01	0.006

Appendix IX. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square	
		Number of lady bird beetle/plant	Percent (%) lady bird beetle/plant
Replication	2	0.099	0.002

Treatment	7	20.19**	0.72**
Error	14	2.014	1.001

Appendix X. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square	
		Number of spider	Percent spider on leaves
Replication	2	0.046	0.06
Treatment	7	13.18**	0.47**
Error	14	2.025	1.001

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

Appendix XI. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square				
		Number of total fruits/plant	Number of healthy fruit/plant	Number of infested fruit/plant	Percent infestation	Reduction over control (%)
Replication	2	1.520	0.017	0.269	1.516	24.18
Treatment	7	39.67**	81.53**	7.89**	16.99*	45.73*
Error	14	2.857	1.012	1.009	1.045	2.198

Appendix XII. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili on the basis of comparative effectiveness

Source of variance	Degrees of freedom	Mean square			
		Percent (%) red mite	Percent (%) aphid	Percent (%) white fly	Percent (%) fruit borer
Replication	2	1.78	0.08	0.03	0.14
Treatment	7	51.23*	20.56**	2.73**	6.65**
Error	14	1.517	1.125	1.017	0.129

Appendix XIII. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square				
		Weight of total fruits	Weight of healthy fruit (g)	Weight of infested fruit (g)	Percent (%) Infestation	Reduction over control (%)
Replication	2	20.98	14.00	16.13	1.20	3.31
Treatment	7	281.19*	103.04*	246.83*	44.52*	54.95**
Error	14	3.991	7.143	3.125	1.523	2.057

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

Appendix XIV. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square		
		Yield (kg/plot)	Yield (t/ha)	Yield increase over control (%)
Replication	2	5.38	24.39	7.01
Treatment	7	13.59*	67.087*	232.38*
Error	14	2.404	8.347	9.165

Appendix XV. Analysis of variance on data with the effects of botanicals and chemical pesticides against pest complex of chili

Source of variance	Degrees of freedom	Mean square			
		Total cost of production (Tk./ha)	Gross return (Tk./ha)	Net return (Tk./ha)	BCR
Replication	2	3096.87	1662.00	1001.04	0.001
Treatment	7	9522.43*	26824.28*	26032.95*	2.62**
Error	14	2604.018	1291.143	4036.76	0.071

** Significant at 0.01 level of probability

* Significant at 0.05 level of probability

Appendix XVI. Rate of different input and output cost

A. Rate of input cost

Sl. No.	Description	Rate
1.	Ploughing with tractor	3000.00 Tk./ploughing/ha
2.	Labour	120.00 Tk./labour/day
3.	Fertilizer	
	i. Compost	350.00 Tk./ton
	ii. Urea	12.50 Tk./kg
	iii. TSP	76.00 Tk./kg
	iv. MP	46.00 Tk./kg
	v. Gypsum	10.00 Tk./kg
4.	Plant (for sowing)	
	i. Chili	0.50 Tk./plant
5.	Insecticide	
	i. Chemical	
	a) Aroslin	50.00 Tk./100 g
	b) Thiolux	57.00 Tk./100 g
	c) Dursban	64.50 Tk./100 ml
	ii. Botanical	
	a) Neem oil	200.00 Tk./litre
	b) Neem leaf extract	100.00 Tk./kg
	c) Neem seed extract	110.00 Tk./kg
	d) Biskatali leaf extract	80.00 Tk./kg
	e) Garlic clove extract	60.00 Tk./kg
6.	Irrigation	600.00 Tk./irrigation
7.	Interest of total input cost	12.00%
8.	Interest of cost of land	12.00%
9.	Miscellaneous	500.00 Tk./ha

B. Rate of output cost

Sl. No.	Description	Rate
1.	Chili	20.00 Tk./kg