SURVEY THE MAJOR INSECT PESTS AND THEIR MANAGEMENT IN DIFFERENT NURSERIES OF GREATER DHAKA CITY

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CERTIFICATE

This is to certify that the thesis entitled **'Survey the Major Insect Pests and their Management in Different Nurseries of Greater Dhaka City'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of Master of Science in Entomology, embodies the result of a piece of *bonafide* research work carried out by Md. Bellal Hossain, Registration number: 13-05762 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2014
Dhaka, Bangladesh

Prof. Dr. Md. Mizanur Rahman
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DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

Thirty nursery of greater Dhaka district were selected for conducting the study. As a part of survey, owners of selected nursery were interviewed and prepared a clear observation through a questionnaire during the period from November 2013 to May 2014. Objective-oriented structured questionnaires were used to identify socio-economic status of the nursery owners, intensity of infestation in different seedlings, major insect pests in nursery and their proportion for specific seedlings, species wise management practices and use of different insecticides for managing these insect pests for specific seedlings or saplings species. Among the nurseries the highest around 50.00% have low level infestation of nursery seedlings or saplings followed by 26.67% nursery in mid infestation level and 3.33% nursery high and sever level infestation of seedlings and saplings. Different insects was recorded from infested seedlings/saplings and the species are thrips, hairy caterpillar, aphid, stem borer, jassid, white fly, green bug, leaf minor and stem fly was recorded. Nursery owners used different insecticides mainly Ripcord, Mancozeb, Dithane, Sevin, Bavistin, Simcaf, Cartap Endofil and used for controlling different insects. The nursery owner's practices (NPs) the highest seedling infestation was recorded from NP_1 (40.00%), whereas the lowest sapling infestation was observed from NP_5 (6.67%) followed by NP_4 (10.00%). The highest BCR was calculated from NP_5 (3.56), while the lowest BCR was observed from NP_1 (2.90). The pesticides combination (ICs) the highest seedling infestation was recorded for IC_1 (43.33%), whereas the lowest seedling infestation was recorded from IC_6 (3.33%) and IC_5 (6.67%) for the management of nursery pests. The highest BCR was recorded for IC_6 (3.01), while the lowest BCR was recorded from IC_1 (2.41) and then IC_2 (2.43) for the management of nursery pests. Among the nursery owner's practices NP_5 (Mechanical, Cultural, Field sanitation) was suitable in terms of insect control and also benefit cost ratio. Among the pesticides combination (ICs) the IC_6 (Mancozeb + Simcaf + Endofil) was suitable in terms of insect control and also benefit cost ratio.

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CHAPTER I

INTRODUCTION

Bangladesh is a densely populated country with an area of 147,570 km^2 and the population is 155 million with the growth rate of 1.34% (BBS, 2013). It is an agro-based country and agriculture accounts for 19.42% of country's GDP and source of employment of 44.4% of its people (Bangladesh Economic Census, 2013). To meet the food demands of this large number of population a lot of crops are grown in our country. Some are sole crops and some are optional. It has a very rich alluvial soil and moderate climate congenial to the growth of various agricultural crops throughout the year. People depend upon agriculture for their employment, poverty alleviation, human resource development and food security. Agriculture supplies raw materials for industrial production and food-stuff for human and animal consumption. Nursery can play a vital role for the optimization of this wide range of agriculture.

Nurseries are used for the artificial regeneration of plants through the use of planting materials like seeds, leaf cuttings, stem cuttings budding, grafting and layering (Anka-Ampong, 2009). It is the areas where planting materials are raised for sowing or planting in gardens or on the field (Hazra *et al*., 2006). Singh (2002) defined a nursery as a place where plants are raised until they are ready for final transplanting in the field or as expressed a place where young plants are raised under intensive management for later transplanting to the field.

According to Khan *et al.* (2004) a total of 1.51 million ha of land would be available for social forestry development in Bangladesh. In plantation programs, nursery is becoming a profitable industry in producing thousands of seedlings and vegetative propagules recently in Bangladesh. New nurseries are being started and existing nurseries expanded to meet the need of increased demand. In addition, people are becoming more and more aware of the importance of high quality seedlings for plantation programs. Most nurseries produce seedlings of the required species with right size, sturdiness and sufficient numbers for the planting

programs. Some people took the nursery programs as their main source of livelihoods and contributing to the plantation programs of the country. Nursery owners and growers sell the seedlings all over the year having a peak period in the rainy season.

Commercial dimension is very much important for any kind of business. It actually searches the answers of why, how, where, who, when, what amount, etc. for purposively running a business more appropriately rendering a desired profit to it (Sandini, 1995). As nursery business in Bangladesh is still at the initial stage, therefore, many of the nursery owners often ignore the details of the commercial perspectives of the business. This is even still not properly addressed by the stake holders of this sector. To bring competence nationally and internationally nurseries and stakeholders involved with it should consider commercial management aspects with due importance. No study so far has been conducted on this particular issue in the nurseries under the greater Dhaka district.

Nevertheless, this study was intended to survey the product and service diversity and their promotional strategies adopted by the selected nurseries in the greater Dhaka district of Bangladesh. The establishment of nurseries has become a major feature of the urban landscape in Dhaka, springing up mainly along major roads and highways, along streets, foot paths and even in private homes. There are an economic activity creating viable employment for a number of families in the country and providing invaluable service to the fast growing landscape and floricultural industries. Poincelot (2004) described nurseries as a means to create opportunities for start-ups or beginners for either full-time or part-time employment.

The present study, undertaken in Dhaka city in documented the nursery pest problems, management practices, patterns of input use, and economic returns in

order to develop a baseline to understanding socio-economic condition that influence nursery business in a profitable manner.

Objectives

- **To study the socio-economic condition of the nursery owners.**
- **To identify the major insect pests and assess the current status on incidence, severity and distribution of insect pests in commercial nurseries.**
- **To investigate the effectiveness of nursery owner' practices (NPs) used for managing nursery pests in different growing areas of Dhaka city.**

CHAPTER II

REVIEW OF LITERATURE

The insect pest of commercially nursery are causes great reduction in output level, which is considered as an important obstacle for economic production of commercial nursery. Nursery is one of the means of crop species multiplication in respect of field and forest crop development although there are many constrains for it's management such as species aspect, climatic factors, management practices, insect pests and diseases.

2.1 Insect pests in nursery

Among them insect pests is considered the important one. Generally the following listed insect pests that attack nursery crop species-

Common name	**Scientific name**	**Order**
Thrips	*Megalurothrips distalis*	Thysanoptera
Hairy caterpillar	*Spilarctia obliqua*	Lepidoptera
Aphid	*Aphis spp.*	Homoptera
Stem borer	*Maruca vitrata*	Lepidoptera
Jassid	*Empoasca kerri*	Homoptera
Whitefly	*Bemisia tabaci*	Homoptera
Green bug	*Nezara viridula*	Homoptera
Leaf miner	*Acrocerphos phacospora*	Lepidoptera
Stem fly	*Ophiomya phaseoli*	Diptera
Epilachna beetle	*Epilachna spp*.	Coleoptera
Semi-loopers	*Diachrysia orochalcea*	Lepidoptera
Bruchids	*Callosobruchus chinensis*	Coleoptera
Galerucid beetle	*Madurisia obscurella*	Coleptera
Green semi-lopper	*Plusia signata*	Lepidoptera

Among the above listed insect pests, thrips, hairy caterpillar, aphid, stem borer, jassid, whitefly, green bug, leaf minor, stem fly are most damaging (Rahman *et al*., 1981).

Thrips

Thrips are the important pests in nursery species. They are small, slim-bodied insects with rasping-sucking mouthparts that puncture plant cells and suck out their contents. Thrips feed on young shoots, flowers, petioles and stigmas; causing deformity of the emerging buds.

Hairy caterpillar

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

Aphids

There are six species of aphids. These species include *Rhopalosiphum padi, Schizaphis graminurn, Sitobion avenae, Metopoliphiurn dirhodum, R. maidis* and *Diuraphis noxia.* Two of those species commonly known as Russian Wheat Aphid (*Diuraphis noxia*) and Bird Cherry-Oat Aphid (*Rhopalosiphum padi*) are considered notorious for their direct and indirect losses.

Russian Wheat Aphid (RWA) is known to be a sporadic insect causing significant losses by spreading out from its origin. The centre of origin for RWA is considered to be the central Asian mountains of Caucasus and Tian Shan. The specie could now be found in South Africa, Western United States, Central and Southern Europe and Middle East. The RWA was first reported in South Africa in 1978 (Walters, 1984), in Mexico during 1980, in United States in 1986 and Canadian Prairie Province during 1988. Direct losses have also been assessed as an increased input cost due to insecticides and indirect losses include reduced yield due to RWA infestation.

Climatic conditions and temperature in particular, plays a significant role in population dynamics of the aphids. A warmer temperature can potentially accelerate the aphid's growth both in terms of number and size, yet, the extreme temperatures can possibly reduce the survival and spread. RWA is known to be present in its three different morphological types: immature wingless females, mature wingless females and mature winged females. Winged mature females or adults spread the population and infection to the surrounding host plants whereas the wingless types or apterous cause damage by curling and sucking the young leaves. Heavily infested plants may typically look prostrated and/or stunted with yellow or whitish streaks on leaves. These streaks, basically, are formed due to the saliva injected by the RWA. The most obvious symptoms due to heavy infestations can be reduced leaf area, loss in dry weight index, and poor cholorophyll concentration. Plant growth losses could be attributed mainly due to reduced photosynthetic activity to plants RWA infestation (Millar *et al*., 1994). The photochemical activity of the plants reportedly inhibited by the RWA feeding from leaves and disruption in electron transport chain.

Jassid

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

Whitefly

The whiteflies cause damage to plant by three means, (i) large population of nymphs and adults suck sap directly from plant greatly reduce yield, (ii) heavy colonization of *B. tabaci* can cause serious damage to some crops due to

honeydew excreted by all stages, particularly the late nymphal instars which encourages growth of “sooty mould” that affect yield both in quantity and quality and (iii) they reduce crop yield through transmission of viral diseases from crop to crop (Kajita and Alam, 1996).

The adult of whitefly is soft and pale yellow, change to white within few hours due to deposition of wax on the body and wings (Haider, 1996). Eggs are laid indiscriminately almost always on the under surface of the young leaves. The whitefly, *B. tabaci* is an important pest worldwide for many vegetable crops as well as tomato. The whiteflies are very small, fragile and active insects, jump from plant to plant with very slight disturbance and because of this there is great difficulty in handling them during experimental work and as well as also management.

Brown and Bird (1992) have pointed out the increased prevalence as well as expanded distribution of whitefly borne viruses during the last decade and resulting devastating impact on crop growth and yield. Yield loss range from 20-100 per cent, depending on the crop, season, vector prevalence and other factors during the growing season.

The whitefly acts as a mechanical vector of many viral diseases for different vegetable crops (Butani and Jotwani, 1984). Young plant may even die in case of severe infestation. The pest is active during the dry season and its activity decreases with the on set of rains. As a result of their feeding the affected parts become yellowish, the leaves become wrinkle, and curl downwards and eventually fallen off. This happens mainly due to viral infection. Yield loss due to *Bean golden mosaic virus* (BGMV) varied from 40-100 %, depending on age, variety.

The adult whitefly is a tiny soft bodied and pale yellow, change to white within a few hours due to deposition of wax on the body and wings (Haider *et al*., 1996). Eggs are laid indiscriminately almost always on the under surface of the young

leaves (Hirano *et al*., 1993). The nymphs are pale, translucent white, oval, with convex dorsum and flat elongated ventral side. The whitefly adults and nymphs feed on the plant sap from the underside of the leaves. They secrete honeydew, which later helps the growth of sooty mould fungus thus reducing the photosynthetic area. The infested plants became weakened due to sucking of the plant sap from the leaves and also due to the reduction of photosynthesis of the infested plant parts (Naresh and Nene, 1980). The infested plant parts become yellowish, the leaves become wrinkle, curl downwards and eventually they fallen off. This happens mainly due to viral infection where the whitefly acts as a mechanical vector of many viral diseases.

Leaf minor

The leaf miner is considered as the most important insect pest of groundnut in India and particularly in rainfed situations (Reddy, 1988). The pest initially appears as a leaf miner causing short blister like mines. Older larvae fold the leaflets and feed within. As a result, the leaflets turn brown, shrivel and dry up. Severly infested crop gives a burnt up appearance and yield losses can reach upto 76 per cent (Anon., 1986).

Oloan *et al*. (2003) reported that the population of leaf miner on selected highland crops was assessed and the percent leaf injury caused by adult and larval leaf miner and effect of leaf miner population and leaf injury on the yield of garden pea, potato, onion, and tomato. Population of leaf miner adult ($8.15/in^2$) and leaf injury (47.5%) were highest in potato. Larval count was highest in onion (3.03/leaf) and leaf injury by leaf miner larva was highest in garden pea (31.25%). Tomato had the lowest count of adult and larval leaf miner and the lowest leaf injury of all the crops tested. Correlation analysis showed that adult and larval populations were significantly correlated with leaf injury, whereby an increase of one leaf miner adult corresponds to 1.76% leaf injury, and an increase of one leaf miner larva corresponds to a 3.06% leaf injury. An increase in leaf injury by leaf miner adult and larva decreases yield by 0.26% and 0.87%, respectively.

Stemfly

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

Stem borer

The adult moth of stem borer is dark brown in color. There is a white half circle spot on the front pair of wings. Hind pair of wings is grayish white in color and moth having light brown spots on the leaf. The larvae are yellowish in color. They enter into the inflorescence and start feeding the flowers, later they cripple leaves together making nets and nets with leaves, flowers. They remain inside the nets hiding themselves and eat the young seeds boring the pods.

Stem borer is a polyphagous pest, which spreads in wide geographical areas and it extends from Cape Verde Islands in the Atlantic, through Africa, Asia and Autralasia, to the South Pacific Islands and from Germany in the north to New Zealand in the south. Rao (1974) stated that in India, *H. armigera* is distributed over a wide range and caused serious losses to many crops, including chickpea, particularly in the semi-arid tropics. Ibrahim (1980) observed that *Heliothis* spp. is of considerable economic importance as pests on many Egyptian crops but *H. armigera* is the most abundant species throughout Egypt.

2.2 Abundance of different insect pests in nursery and their management

The efficacies of four systemic neonicotinoid insecticides applied to potted avocado trees at manufacturer-recommended rates were assessed against the avocado thrips, Scirtothrips perseae Nakahara by Byrne *et al*. (2007). At the time of treatment, fully expanded first-flush young leaves were tagged for identification, and a proportion of these leaves was used in bioassays with second-instar thrips. At 7 weeks post-treatment, a second flush of leaves had fully expanded on the trees, and these leaves were included in additional bioassays comparing avocado thrips mortality on both first- and second-flush leaves. In bioassays with first-flush leaves, imidacloprid (273 mg AI pot^{-1}) was the most effective insecticide, providing at least 70% mortality of thrips for 14 weeks. Thiamethoxam (137 mg AI pot^{-1}), clothianidin (109 mg AI pot^{-1}) and dinotefuran (241 mg AI pot^{-1}) provided good control in bioassays that were conducted within 4 weeks of treatment, but thereafter their efficacies were inconsistent. In bioassays with second-flush leaves, imidacloprid provided at least 70% mortality up to 9 weeks after the insecticide application. Thereafter, mortality declined to 30% or lower. Bioassays with second-flush leaves collected from trees treated with thiamethoxam, clothianidin and dinotefuran resulted in unacceptably low thrips mortality. Monitoring of imidacloprid and thiamethoxam residues by ELISA showed that the greater persistence of imidacloprid in both first and second leaf flushes was due to a steadier uptake of this material. Although thiamethoxam residues rose quickly within the first leaf flush, levels had already begun to dissipate by the time the second leaf flush had started to develop.

In favourable years, thrips can be considered a key pest in Eastern Sicily lemon orchards. In the period 2000-02, biorational active ingredients were tested by Conti *et al*. (2004) on lemon to evaluate their efficacy and selectivity. Azadirachtin, abamectin, pyrethrum and rotenone were tested both under nursery and field condition. Abamectin achieved good efficacy, but only for a short period of time after the application. The effectiveness of the other compounds was insufficient. The treatments affected, in some trials, the density of phytoseiids

mites. Further tests are necessary to demonstrate the potential of biorational compounds in IPM programmes.

Calo *et al*. (2006) reported that statistics concerning nursery production of vines show a decline in numbers in the 25 years from 1975, which continued, after a slight increase in 2001-02, and a tendency for red wine varieties and typically Italian varieties to increase. Figures for grafted cuttings in 2005-06 show that the top 20 grape varieties represent only 60% of the total compared with 70% in earlier years. The decline is seen as reflecting a greater concentration on quality as opposed to quantity. The decline in nursery production has been followed by a similar decline in new plantings. Among the typically Italian varieties, Cattarratto bianco lucido has shown a striking upsurge. These statistics offer an objective basis for planning the future of the "Italian vineyard".

Anselmi *et al*. (2007) reported some possible integrated control methods are suggested. Of particular importance is the genetic resistance of the plants to diseases. Regulatory inspections and certifications of nursery plant production, and quarantine rule observation during importation of plant propagative materials are important. In the current urban tree and shrub cultivation, periodic monitoring, silvicultural practices, infected host eradication, sanitation, elimination of pathogens from plants, creating unfavourable pathogen conditions, and improvement of plant growing conditions are considered.

Thrips palmi Karny, the melon thrips, is a polyphagous pest that has spread widely in tropical and subtropical regions reported by Cannon *et al*. (2007). It is absent from Europe, although outbreaks have occurred in the Netherlands (1988-98), the UK (2000-01) and most recently. An outbreak of T. palmi occurred in Sussex in 2000. It was already well established when the UK Plant Health Service first notified. High populations were discovered in two glasshouse sites on the same nursery, growing all-year-round chrysanthemums. An intensive, largely chemically based eradication programme was carried out, with applications of aerosol 'space' treatments, systemic and foliar insecticides. Other measures

included the use of sticky yellow sheets, methyl bromide fumigation of flowerbeds and plastic mulches. Together, these controls resulted in the collapse of the outbreak, within 7 months. Eradication was subsequently declared after freedom from the pest had occurred over two complete cropping cycles.

Sadowski *et al*., (2007) stated that 'Gloster' apple trees on 'M.9 EMLA' rootstock, raised in different ways in the nursery, were planted in Central Poland, in November 2000. One-year-old branched nursery trees served as a control. Two-year-old nursery trees with a one-year-old crown were obtained either from budding or from grafting. Both were trained in the nursery either by traditional heading or as Dutch "knip-boom" trees. Some trees from budding, which feathered in the 2nd year of nursery, were allowed to develop two-year-old crowns in the 3rd year. The standard spacing was 3.25x1.40 m. Part of the one-year-old trees were planted at a 1.0 m in-row spacing and part of the two-year-old trees, trained by traditional heading were planted at a 2.0 m in-row spacing. At planting and after three years in the orchard, trees planted as one-year-olds were the smallest and those planted as two-year-olds with a two-year-old crown were the largest. Trees trained in the nursery by traditional heading surpassed the "knip-boom" trees in vigour, but not in cropping. Yield per tree in 2002 and for two years (2002 and 2003) was the highest from trees planted as two-year-olds with a two-year-old crown, and the lowest from trees planted as one-year-olds. In 2003, a higher yield was obtained from two-year-old trees, which were planted at 2 m in-row spacing than from similar trees planted at the standard 1.4 m spacing. The cumulative yield efficiency was higher for all types of two-year-old nursery trees than for one-year-old trees.

The incidence of citrus leaf miner (*Phyllocnistis citrella*), thrips (*Scirtothrips* spp.), mites (*Panonychus citri* and *Eutetranychus* spp.) and leaf folder (*Psorosticha zizyphi*) was monitored in citrus nurseries predominated by rough lemon (*Citrus jambhiri*) and Rangpur lime (*C. limonia*) rootstocks in 1999 and 2000 in Maharashtra, India by Shivankar and Rao (2003). The damage caused by the pests was assessed. Percentage infestation of citrus leaf miner was higher on

rough lemon than on Rangpur lime. Infestation was higher in spring and summer flushes (61.8-65.5% and 53.9-58.4% on rough lemon and 35.6-52.7% and 34.3-61.8% on Rangpur lime, respectively) than in autumn flushes (9.4-21.9% on rough lemon and 15-18.8% in Rangpur lime). Leaf folder population was observed only in spring and summer flushes (4.9-21.9 and 4.7-4.9 larvae per 5 plants, respectively). Thrip population was highest during the spring (3.8-4.9 per 5 cm twig). Thrip population was greater on Rangpur lime than on rough lemon. Mite population was higher during autumn (9.8-12.8/leaf) than summer (3.5-9.1/leaf) and spring (2.1-5.1/leaf) seasons. The infestation of citrus leaf miner and leaf folder was positively correlated with maximum and minimum temperatures, rainfall and wind velocity, whereas it was negatively correlated with relative humidity. Thrip infestation was negatively correlated with weather parameters except with wind velocity. Mite incidence was negatively correlated with maximum temperature and wind velocity, and positively correlated minimum temperature, relative humidity and rainfall.

Prays citri Mill. [Lepidoptera: Yponomeutidae] is a key pest of the nursery trees in the citrus industry. In the years 2007, 2010, 2011 the efficacy of spray application of phosmet, flufenoxuron and *Bacillus thuringiensis* var. kurstaki has been evaluated by Conti andFisicaro (2012) on 2 years lemon trees, in a nursery of the North coast of Sicily. The applications have been carried out weekly in May and June, for a total of 6 treatments per year. The efficacy has been reported as mean percentage of infested organs (flowers, fruits and shoots) and mean number of living stages per single organ. In 2007 the applications achieved poor protection of flowers and fruits; on young shoots, the active ingredients reduced significantly the infestation. In 2010 the applications of the compounds resulted in a greater control of the pest on flowers and fruits compared with 2007; on young shoots, the highest level of efficacy was achieved in the plot sprayed with flufenoxuron followed by phosmet. The results of *B. thuringiensis* were intermediate. In 2011 the active ingredients reduced similarly the infestation on

flowers and fruits; on young shoots, flufenoxuron achieved the greatest efficacy, followed by B. thuringiensis and phosmet.

Son *et al*. (2014) studied the effects of different nutrient solution concentrations and amount on tomato plant growth and fruit quality and chemical properties. Results showed that as for tomato seedlings in nursery, the plant height, stem diameter, dry and fresh weight and other indicators of growth were significantly higher than control and other treatments. After transplanting, with the increasing of nutrient solution concentration and dosage, the pH of cultural medium decreased and the range of these changes were between 6.79 to 6.29, but the EC values of the substrate increased and these changes were between 1.5 to 2.77. 1/4 Hoagland treatment was the most favorable for the growth of tomato, but it demanded more nutrient solution at flowering stage. The contents of soluble solids, soluble sugar and soluble protein were highest in tomato fruit under treatment 1/2 Hoagland by adding 900 mL solution every time. At fruiting period adding 1/2 Hoagland 900-1,200 mL nutrient solution can improve fruit quality and yield.

The repellent, antifeedant and ovicidal properties of the extracts of *Acorus calamus, Croton oblingifolis, Strychnos nux-vomica*, *Santalum album, Simarouba glauca* [*Quassia simarouba*] and *Vitox negundo* against *S. litura* infesting vegetables in Bangalore, Karnataka, India were determined under laboratory conditions by Murthy *et al.* (2006). All the extracts exhibited repellent, antifeedant and ovicidal properties, with *Acorus calamus* and *V. negundo* exhibiting the highest biological properties, regardless of the concentration.

Ghatak *et al.* (2005) conducted an experiment in West Bengal, India to investigate the biological efficacy of indigenous plant products in controlling *S. littoralis.* Petroleum ether extracts from seeds of *Pachyrhizus erosus* (PE) and *Annona squamosa* (AS) at 1,2 and 3% concentration; Neem plus 1500 ppm at 0.5, and 2% concentration ; and Monocil 36 SL [monocrotophos] at 0.03, 0.05, and 0.07% concentration were sprayed on third instar larvae *S. littoralis*, and effects were

assessed at 12, 24, 48, 72 and 96 h after treatment. Larval mortality under PE, AS and neem was 40.00-83.33, 46.66-70.00 and 40.00-60.00, respectively after 96 h treatment. Larval mortality due to monocil was 76.66-86.66 even at 48 h after treatment. Based on LC_{50} values, monocil was the most toxic pesticide, while seed extract of AS was the least toxic.

Sharma *et al.* (1999) conducted and experiment for the effect of host plants like castor (*Ricimus communis*), cabbage, cauliflower, tomatoes and wild cabbage and also the effect of neem oil on food utilization indices of *S. litura.* They stated that, cauliflower was the most preferred host. Neem oil markedly decreased feeding by *S. litura* larva on these plants.

Neem oil (*S. indica*) at 8 and 16% exhibited complete repellent and antifeedant effect against larvae of *S. litura* on *Vigna mungo* leaves. At 0.5-4% repellency and antifeedant activity increased with increasing concentration. Neem oil at 0.5 and 1.0% lost its antifeedant property after 5 days (Venkateswarly *et al.*,1998).

Kumar *et al.* (1997) investigated the effect of exudates from reddish terminal leaves of neem, *Azadirachta indica* on *S. litura*. A significant increase in the larval mortality, antifeedancy and ovipositional repellency was found after treatment with acetone extracts of neem leaf exudates to fifth instar larvae. Reduced consumption, growth and nutritional efficiency were evident. Extended larval and pupal durations and reduced longevity and fecundity were observed by neem leaf extract treatment.

The repellency, antifeedant activity and development period increased with increase in concentration of biosol, neemark, repelin and neem oil. Moreover, adult emergence, growth, survival, larval and pupal weight, number of eggs laid and hatchability of eggs decreased with increase in concentration and neem oil had the greatest effects, followed by neemark, biosol and repelin (Rao *et al.*, 1993).

A field experiment was conducted in Karnataka, India, during 1998-99 and 1999-2000 by Mallapur *et al*. (2001) to evaluate the efficacy of the premix, Match [difenzoquat] + profenofos (at 1 and 1.5 litre/ha), against chilli (*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 chilli (*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.

Nelson and Natarajan (1994) carried out studies in 1990-91 and 1991-92 in Paramakudi, Tamil Nadu, India observations were made on fruit borer populations, damage, fruit set percentage and yield of chillies. 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.

Nelson and Natarajan (1994) conducted an experiment during a field trial in 1990-91 in Paramakudi, Tamil Nadu, the moult inhibitor diflubenzuron and a nuclear polyhedrosis virus reduced damage by fruit borers on chillies. In plots treated with diflubenzuron, Larval/pupal intermediaries were observed.

In plot experiments conducted by Torner *et al*. (1993) in Spain, the presence of a *Solanum nigrum* plant at 10, 50, 80 and 110 cm from a *Capsicum annuum* plant caused yield losses of 59, 48, 26 and 9%, respectively. It was concluded that one *S. nigrum* every 2.5 m in the crop row resulted in a *C. annum* yield loss of 34%.

Frank *et al*. (1992) carried out a field experiment at Frederick, Maryland, in 1985-86 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.

CHAPTER III

METHODOLOGY

Thirty nurseries of greater Dhaka district were selected for conducting the study. A huge number of commercial nursery was present in Dhaka and most of them have a long history of growing seedlings and saplings production and distribution. As a part of survey, total of 30 nursery owners were interviewed and make a clear observation through a questionnaire survey during the period from November 2013 to May 2014.

3.1 Methods of survey

Thirty nurseries in different locations were greater Dhaka district were selected randomly for questionnaire survey. The detailed information of the selected nursery has been presented in Appendix 1. Objective-oriented structured questionnaires were used to identify socio-economic status of the nursery owners, intensity of infestation in different species of seedlings, major insect pests in nursery and their proportion for specific seedlings, species wise management practices and use of different insecticides for managing these insect pests for specific seedlings or saplings species.

The study was conducted with staying close contact with the nursery owners and also visit and keen observation of the different plant species of different during the entire experimental period and a pre-tested survey instruments were used for the collection of data. Several factors were hypothesized to find out the affect of management practices during the study period, including nursery owner characteristics, nursery structure and management, source of pesticide information, and pesticide and pest management perceptions etc. Among nursery owner characteristics, the specific variables included in the survey are: land holding status, pest control training receiving status, duration of training, age of the nursery owners, education level of the nursery owners, how long they have been involved with nursery business.

During the study period total 16 species of different seedling and saplings were identified that were available of the nursery. The 16 species of nursery seedling or saplings were finalized for data collection. The species were mango, litchi, guava, jujube, pomegranate, malta, lemon, jambura, hog plum, sapota, papaya, eggplant, chilli, rose, marigold and beli. Among the selected species 20 seedlings or saplining of each species were tagged for data collection. These seedlings were kept under keen observation for recording infestation level. Infestation level was recorded in 6 major categories in nursery wise and species wise and they were no infestation (0% infested plant), low infestation (1-4% infested plant), mild infestation (5-10% infested plant), moderate infestation (11-30% infested plant), high infestation (31-50% infested plant) and severe infestation above 50% infested plant).

Major insect pests of the different crop species also recorded as per observation. During the study period it was also recorded the data on different insecticides that the owners used in controlling insect pests for specific species.

3.2 Data processing, analysis and output generation

For impact assessment, different nursery owners' practices (NPs) and synthetic insecticides used were identified and their impacts were assessed. Nursery wise information of NPs was analyzed by considering three recorded from each specific different NPs and chemical used treated as replications.

The data obtained for different characters were statistically analyzed to find out the significance of the different NPs and synthetic insecticides used by the respondents' nursery on seedling and sapling infestation, production cost, net return, benefit cost ratio and abundance of insect pest for different NPs and insecticides used. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test using MSTATC program. The significance of the difference among the different combinations for different characters was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

In this chapter the findings of the study were presented in accordance with the objectives of the study and possible interpretation of the recorded information also presented. The chapter has five sections. The first section deals with the characteristics of the nursery owners. The second section deals with the insect pests infestation of nursery seedlings. The third section deals with the majors insect pests of nursery plant and chemical insecticides used for managing these pests by the nursery owners. The fourth section deals with different nursery owner's practices for managing nursery pests in relation to benefit cost ratio. The fifth section deals with the insecticides used for managing nursery pests in relation to benefit cost ratio and pest abundance.

4.1 Characteristics of the nursery owner

There are different interrelated characteristics of the nursery owners that influence their knowledge on the management practices of nursery. It was therefore, hypothesized that the characteristics of the nursery owners under the study would have an effect on the management of insect pests of nursery. However, the most important features of six selected characteristics of the nursery owner such as land holding status, pest control training receiving status, duration of training, age, education level, period of involved with nursery business. Character wise summary of descriptive statistics of nursery owners are presented in Table 1 to 6.

4.1.1 Land holding status

Based on land holding status the nursery owners were classified into three categories as own land, leased in ownership and shared ownership (Table 1). Among the respondents, the highest (83.33%) nursery owners have own land, where as 13.33% have leased in ownership and only 3.33% nursery owner were shared ownership of their nursery land.

Table 1. Status of the nursery owners according to their land holding

Categories	Respondents'	
	Number	Percent
Own land	25	83.33
Leased in ownership	4	13.33
Shared ownership	1	3.33
Total	30	100

4.1.2 Training exposure status

On the basis of training exposure, the nursery owners were classified into two categories as received pest control training and have not pest control training (Table 2). Among the respondents, the highest (96.96%) nursery owners received training on pest management and only 3.33% have not received any training on pest management.

Table 2. Status of the nursery owners according to their pest control training exposure

Categories	Respondents'	
	Number	Percent
Received pest control training	29	96.67
Didn't received pest control training	1	3.33
Total	30	100

4.1.3 Duration of training exposure status

On the basis of training exposure, the nursery owners were classified into three categories as low, medium and high training exposure (Table 3). Among the respondents, the highest (56.67%) nursery owners received low level training on pest management and only 13.33% received high level training.

Table 3. Status of the nursery owners according to their duration of training exposure

Categories	Respondents'	
	Number	Percent
Low training exposure (below 10 days)	17	56.67
Medium training exposure (10-20 days)	9	30.00
High training exposure (above 20 days)	4	13.33
Total	30	100

4.1.4 Age of the nursery owners

Age of the nursery owners were classified into three categories as young, middle and old aged (Table 4). Among the respondents, the highest (53.33%) nursery owners were middle aged, 40.00% were young aged and only 6.67 percent were old aged.

Table 4. Status of the nursery owners according to their age

Categories	Respondents'	
	Number	Percent
Young aged (below 35 years)	12	40.00
Middle aged (35-50 years)	16	53.33
Old aged (above 50 years)	2	6.67
Total	30	100

4.1.5 Educational background of the nursery owners

Level of education of the nursery owners were classified into four categories as can sign only, primary education, secondary education and above secondary education (Table 5). Among the respondents, the highest (63.33%) nursery owners were educated at secondary level, 16.67% were above secondary level, 13.33% in primary level educated and only 6.67% can sign only.

Table 5. Category of the nursery owners according to their education

Categories	Respondents'	
	Number	Percent
Can sign only (0.5)	2	6.67
Primary education (1-5)	4	13.33
Secondary education (6-10)	19	63.33
Above secondary (above 10)	5	16.67
Total	30	100

4.1.6 Duration of involvement in nursery business

Duration of involvement in nursery business of the nursery owners were classified into three categories as short term involvement, mid term involvement and long term involvement (Table 6). Among the respondent the highest (56.67%) nursery owners have mid term involvement with nursery business, 26.67% have short term involvement and 16.67% have involvement for long term in nursery business.

Table 6. Distribution of the nursery owners according to their duration of involvement in nursery business

Categories	Respondents'	
	Number	Percent
Short term involvement (below 5 years)	8	26.67
Mid term involvement (5-10 years)	17	56.67
Long term involvement (above 10 years)	5	16.67
Total	30	100

4.2 Insect pest infestation of nursery seedlings

Infestation of different species of nursery plant was assessed in species wise and then categories the nursery based on infestation level which were presented in Table 7. Among the nurseries the highest around 50.00% have low level infestation of nurseries seedlings or saplings followed by 26.67% nursery in mid infestation level and 3.33% nursery high and severe level infestation of seedlings and saplings.

Table 7. Distribution of different nursery according to the level of infested plant in their nursery

Categories	Respondents'	
	Number	Percent
No infestation (0% infested plant)	3	10.00
Low infestation (1-4% infested plant)	15	50.00
Mild infestation (5-10% infested plant)	8	26.67
Moderate infestation (11-30% infested plant)	2	6.67
High infestation (31-50% infested plant)	1	3.33
Severe infestation (above 50% infested plant)	1	3.33
Total	30	100

In case of species wise infestation, the highest no infestation of seedlings 83.87% was recorded in marigold species followed by papaya (80.95%), whereas the lowest no infestation seedlings was recorded for mango seedlings (4.48%) followed by litchi (10.91%) (Table 8). In low infestation, the highest low infestation of seedlings 59.89% was recorded in eggplant species followed by rose (48.57%), whereas the lowest low infestation seedlings was recorded for mango seedlings (5.97%) followed by beli (10.00%). In mild infestation, the highest mild infestation of seedlings 81.34% was recorded in mango species followed by guava (69.31%), whereas the lowest mild infestation seedlings was recorded for marigold seedlings (1.08%) followed by papaya (4.76%). In moderate infestation, the highest moderate infestation of seedlings 14.29% was recorded in jujube species followed by Hog plum (10.34%), whereas the lowest moderate infestation

of seedlings was recorded for marigold seedlings (1.08%) followed by beli (1.67%). In high infestation, the highest high infestation of seedlings 5.71% was recorded in jujube species followed by sapota (5.56%), whereas the lowest high infestation of seedlings was recorded for chilli seedlings (0.63%) followed by marigold (1.08%). In severe infestation, the highest severe infestation of seedlings 5.56% was recorded in sapota species followed by beli (5.00%), whereas the no severe infestation of seedlings was recorded for rose and marigold.

Table 8. Plant infestation levels observed in the nurseries

Crop species	Level of infested plant (%)					
	No infestation (0% infested plant)	Low infestation (1-4% infested plant)	Mild infestation (5-10% infested plant)	Moderate infestation (11-30% infested plant)	High infestation (31-50% infested plant)	Severe infestation (above 50% infested plant)
Mango	4.48	5.97	81.34	5.60	1.87	0.75
Litchi	10.91	20.00	58.18	7.27	3.64	0.00
Guava	16.93	10.05	69.31	2.12	1.06	0.53
Jujube	14.29	22.86	40.00	14.29	5.71	2.86
Pomegranate	14.81	22.22	55.56	3.70	3.70	0.00
Malta	11.11	25.93	51.85	3.70	3.70	3.70
Lemon	57.14	32.14	7.14	1.79	1.79	0.00
Jambura	53.85	23.08	11.54	3.85	3.85	3.85
Hog plum	17.24	24.14	41.38	10.34	3.45	3.45
Sapota	22.22	44.44	16.67	5.56	5.56	5.56
Papaya	80.95	7.14	4.76	2.38	2.38	2.38
Eggplant	24.06	59.89	9.63	2.14	2.67	1.60
Chili	42.41	46.20	7.59	1.90	0.63	1.27
Rose	34.29	48.57	11.43	2.86	2.86	0.00
Marigold	83.87	12.90	1.08	1.08	1.08	0.00
Beli	71.67	10.00	8.33	1.67	3.33	5.00

4.3 Majors insect pests of nursery plant and chemical insecticides used for managing the prevailing insect pests

Different insects were recorded from infested seedlings/saplings and the species were thrips, hairy caterpillar, aphid, stem borer, jassid, white fly, green bug, leaf miner and stem fly (Table 9).

Table 9. Status of different nurseries according to the major insect pests in infesting major plant species

Crop species	Major insect pests (%)								
	Thrips	Hairy caterpillar	Aphid	Stem borer	Jassid	White fly	Green bug	Leaf miner	Stem fly
Mango	26.92	11.54	15.38	7.69	0.00	11.54	3.85	7.69	15.38
Litchi	13.79	6.90	17.24	24.14	3.45	13.79	3.45	10.34	6.90
Guava	20.83	4.17	20.83	12.50	16.67	0.00	8.33	4.17	12.50
Jujube	6.25	15.63	21.88	12.50	6.25	12.50	6.25	3.13	15.63
Pomegranate	3.70	11.11	7.41	14.81	7.41	18.52	25.93	3.70	7.41
Malta	13.89	5.56	19.44	11.11	8.33	2.78	11.11	22.22	5.56
Lemon	17.65	8.82	17.65	5.88	11.76	2.94	26.47	5.88	2.94
Jambura	25.81	3.23	9.68	6.45	19.35	9.68	6.45	3.23	16.13
Hog plum	13.51	32.43	2.70	8.11	10.81	16.22	5.41	2.70	8.11
Sapota	4.55	9.09	18.18	9.09	36.36	4.55	9.09	4.55	4.55
Papaya	12.50	4.17	20.83	4.17	4.17	16.67	8.33	4.17	25.00
Eggplant	25.58	9.30	16.28	4.65	6.98	20.93	4.65	2.33	9.30
Chili	12.50	18.75	6.25	31.25	0.00	6.25	18.75	6.25	0.00
Rose	16.67	2.78	22.22	8.33	0.00	13.89	5.56	19.44	11.11
Marigold	27.66	23.40	8.51	10.64	2.13	19.15	4.26	2.13	2.13
Beli	12.00	8.00	12.00	24.00	8.00	16.00	4.00	0.00	16.00

Nursery owners used different pesticides mainly Ripcord, Mancozeb, Dithane, Sevin, Bavistin, Simcaf, Cartap Endofil and used for controlling different insects and species wise use of pesticides presented in Table 10.

Table 10. Distribution of different nursery according to the commonly used major pesticides in different major plant species in their nursery during the study period

Crop species	Use of different pesticides (%)							
	Ripcord	Mancozeb	Dithane	Sevin	Bavistin	Simcaf	Cartap	Endofil
Mango	16.67	6.67	23.33	3.33	13.33	6.67	13.33	16.67
Litchi	6.67	26.67	23.33	0.00	3.33	20.00	6.67	13.33
Guava	23.33	10.00	6.67	3.33	16.67	10.00	20.00	10.00
Jujube	33.33	6.67	3.33	20.00	10.00	0.00	10.00	16.67
Pomegranate	30.00	6.67	30.00	0.00	0.00	16.67	13.33	3.33
Malta	16.67	3.33	3.33	13.33	23.33	6.67	26.67	6.67
Lemon	10.00	26.67	16.67	10.00	30.00	3.33	3.33	0.00
Jambura	20.00	3.33	3.33	13.33	6.67	26.67	23.33	3.33
Hog plum	26.67	6.67	3.33	16.67	10.00	23.33	13.33	0.00
Sapota	22.22	44.44	16.67	5.56	5.56	5.56	0.00	0.00
Papaya	16.67	20.00	3.33	0.00	10.00	13.33	6.67	30.00
Eggplant	6.67	16.67	23.33	3.33	3.33	16.67	10.00	20.00
Chili	16.67	16.67	3.33	20.00	6.67	13.33	16.67	6.67
Rose	20.00	3.33	10.00	16.67	26.67	10.00	10.00	3.33
Marigold	10.00	16.67	3.33	23.33	6.67	10.00	23.33	6.67
Beli	26.67	6.67	6.67	6.67	3.33	16.67	6.67	26.67

4.4 Different nursery owner's practices for managing nursery insect pests and their impacts on benefit cost ratio including insect pests abundance during the study period

The nursery owner's practices (NPs) and 30 selected nurseries for pest management is calculated and analyzed. Accordingly, the study reveals a total of 5 NPs for nursery pest management, which may be designated as follows:

NP_1	Chemical control
NP_2	Chemical and Mechanical control
NP_3	Chemical, Mechanical and Cultural control
NP_4	Chemical, Mechanical and Field sanitation control
NP_5	Chemical, Mechanical, Cultural and Field sanitation control

4.4.1 Management practices of nursery owners (NPs)

The nursery owners management practices have been shown in Table 11. Data revealed that, the nursery owners (43.33%) practicing NP_1 followed by NP_4 (23.33%) and NP_2 (16.67%) and the lowest nursery owners (6.67%) practicing NP_5 followed by NP_3 (10.00%) for the management of nursery pests. The findings indicate that the use of only chemicals still highly dominate in the nursery owners' practice for management insects of nursery insect pest. However, a slight change has occurred in the sole reliance on insecticide with some inclusion of some other options like cultural practice, mechanical control and field sanitation. But surprisingly although the options like mechanical control, cultural practices and field sanitation altogether were not used alone without any chemicals. Many of the nursery owners' were found to solely depend on chemical control.

Table 11. Pest management practices and their effects on seedlings and saplings infestation in the nurseries

Practices	Practicing nursery owners (%)	Seedlings infestation (%)	Saplings infestation (%)
NP_1	43.33 a	36.67 a	40.00 a
NP_2	16.67 c	26.67 b	30.00 b
NP_3	10.00 d	23.33 b	13.33 c
NP_4	23.33 b	10.00 c	10.00 d
NP_5	6.67 e	3.33 d	6.67 e

$LSD_{(0.05)}$	3.04	4.63	2.99
CV(%)	5.22	4.78	6.12

4.4.2 Seedlings infestation

For the management of nursery pests, the highest seedling infestation was recorded from NP_1 (40.00%) followed by NP_2 (30.00%) and then NP_3 (13.00%), whereas the lowest sapling infestation was observed from NP_5 (6.67%) followed by NP_4 (10.00%) (Table 11).

4.4.3 Saplings infestation

The highest sapling infestation was recorded from NP_1 (36.67%) followed by NP_2 (26.67%) and NP_3 (23.33%), while the lowest seedling infestation was observed from NP_5 (3.33%) followed by NP_4 (10.00%) for the management of nursery pests (Table 11). Data revealed that combination of chemical, mechanical, cultural control and field sanitation practices was more effective than the sole one for management of nursery insect pests.

4.4.4 Production cost

The highest production cost was calculated from NP_5 (BDT 45255) followed by NP_4 (BDT 44566) and NP_3 (BDT 44205), while the lowest production cost was observed from NP_1 (BDT 42455) followed by NP_2 (BDT 43150) for the management of nursery insect pests (Table 12). Data revealed that combination of chemical, mechanical, cultural control and field sanitation practices required the highest production cost than the sole one for management of nursery insect pests.

4.4.5 Net return

The highest net return was found from NP_5 (BDT 161240) followed by NP_4 (BDT 152560) and NP_3 (BDT 145340), while the lowest net return was observed from NP_1 (BDT 123250) followed by NP_2 (BDT 134360) for the management of nursery insect pests (Table 12). Data revealed that highest net return was recorded from the combination of chemical, mechanical, cultural control and field sanitation practices required the highest production cost than the sole one for management of nursery insect pests by the nursery owners.

Table 12. Nursery owner practices for nursery pest management and their effects on production cost, net return and benefit cost ratio (BCR)

Practices	Production cost (BDT)	Net return (BDT)	BCR
NP_1	42455 e	123250 e	2.90 e
NP_2	43150 d	134360 d	3.11 d
NP_3	44205 c	145340 c	3.29 c
NP_4	44566 b	152560 b	3.42 b
NP_5	45255 a	161240 a	3.56 a
$LSD_{(0.05)}$	345.88	867.55	0.132
CV(%)	3.89	6.22	5.43

4.4.6 Benefit cost ratio (BCR)

The highest BCR was calculated from NP_5 (3.56) followed by NP_4 (3.42) and NP_3 (3.29), while the lowest BCR was observed from NP_1 (2.90) followed by NP_2 (3.11) for the management of nursery insect pests (Table 12). Data revealed that although combination of chemical, mechanical, cultural control and field sanitation practices was expensive than the others but from this combination the nursery achieved maximum benefit.

4.4.7 Number of insects/seedlings

Number of insects/seedlings was recorded from infested seedlings/saplings and different insect species like as thrips, hairy caterpillar, aphid, stem borer, jassid, white fly, green bug, leaf miner and stem fly were recorded. The highest number of insects was recorded from NP_1, whereas the lowest number was observed from NP_5 for all the recorded species (Table 13). The combination of chemical, mechanical, cultural control and field sanitation practices were more effective than the others.

Table 13. Nursery owner practices for nursery insect pest management and their effects on insect pests abundance in nurseries

Practices	Number of insects/seedlings								
	Thrips	Hairy caterpillar	Aphid	Stem borer	Jassid	White fly	Green bug	Leaf miner	Stem fly
NP_1	4.22 a	2.18 a	5.22 a	2.89 a	1.36 a	2.55 a	3.05 a	1.25 a	1.22 a
NP_2	4.16 ab	2.02 b	3.16 b	2.33 b	1.21 b	2.21 b	2.66 b	1.03 b	0.00 b
NP_3	4.02 b	1.67 c	2.54 c	2.05 c	0.00 c	1.98 c	1.35 c	0.00 c	0.00 b
NP_4	3.56 c	1.58 de	2.13 d	1.95 cd	0.00 c	1.33 d	0.00 d	0.00 c	0.00 b
NP_5	3.12 d	1.45 e	1.55 e	1.83 d	0.00 c	0.00 e	0.00 d	0.00 c	0.00 b
$LSD_{(0.05)}$	0.154	0.139	0.327	0.124	0.402	0.291	0.261	0.162	0.108
CV(%)	5.89	4.18	3.96	5.07	6.17	4.38	5.09	4.29	3.89

4.5 Chemical insecticides used for managing nursery insect pests and their impacts on abundance

The insecticides combination (ICs) for nursery insect pest management as reported by the entire 30 nursery together was primarily into different group. Accordingly, the study reveals a total of 6 ICs for nursery insect pests management, which may be designated as follows:

IC_1	Ripcord
IC_2	Ripcord + Mancozeb
IC_3	Ripcord + Mancozeb + Bavistin
IC_4	Ripcord + Mancozeb + Cartap
IC_5	Mancozeb + Dithane + Sevin
IC_6	Mancozeb + Simcaf + Endofil

4.5.1 Management practices of nursery owners

The nursery owners were using different combination of insecticide that have been shown in Table 14. Data revealed that, the nursery owners practicing the highest (46.67%) for IC_1 followed by IC_2 (23.33%), IC_3 (13.33%) and IC_4 (10.00), whereas the lowest nursery owners (3.33%) practicing IC_5 and IC_6 for the management of nursery insect pests. The findings indicate that most of the nursery owners used only one type of insecticides.

Table 14. Chemical insecticides used by the nursery owners' for nursery insect pests management and their effects on farmers' practice and seedlings and saplings infestation in nursery

Insecticide combinations	Practicing nursery owners (%)	Seedlings infestation (%)	Saplings infestation (%)
IC_1	46.67 a	43.33 a	53.33 a
IC_2	23.33 b	16.67 b	23.33 b
IC_3	13.33 c	16.67 b	10.00 c
IC_4	10.00 c	13.33 c	6.67 d
IC_5	3.33 d	6.67 d	3.33 e
IC_6	3.33 d	3.33 e	3.33 e
$LSD_{(0.05)}$	3.451	2.067	2.581
CV(%)	5.09	6.11	4.45

4.5.2 Seedling infestation

The highest seedling infestation was recorded for IC_1 (43.33%) followed by IC_2 (16.67%), IC_3 (16.67%) and then IC_4 (13.33), whereas the lowest seedling infestation was recorded from IC_6 (3.33%) and IC_5 (6.67%) for the management of nursery pests (Table 14). The findings indicate that combination of different types of insecticides reduced the infestation level of nursery seedlings.

4.5.3 Sapling infestation

The highest sapling infestation was recorded for IC_1 (53.33%) followed by IC_2 (23.33%), IC_3 (10.00%) and then IC_4 (6.67), whereas the lowest sapling infestation was recorded from IC_6 (3.33%) and IC_5 (3.33%) for the management of nursery pests (Table 14). The findings indicate that combination of different types of insecticides reduced the infestation level of nursery saplings.

4.5.4 Production cost

The highest production cost recorded for IC_6 (BDT 59675) followed by IC_5 (BDT 58330), IC_4 (BDT 57755) and then IC_3 (56280), while the lowest production cost was recorded from IC_1 (BDT 51230) and then IC_2 (BDT 55450) for the management of nursery pests (Table 15). The findings indicate that combination of different types of insecticides involved more cost than sole one.

Table 15. Chemical used by the farmers' for nursery pest management and their effects on management cost, net return and Benefit Cost Ratio (BCR)

Insecticide combinations	Production cost (BDT)	Net return (BDT)	BCR
IC_1	51230 f	123450 f	2.41 e
IC_2	55450 e	134870 e	2.43 de
IC_3	56280 d	145550 d	2.59 c
IC_4	57755 c	151260 c	2.62 c
IC_5	58330 b	168650 b	2.89 b
IC_6	59675 a	179350 a	3.01 a
$LSD_{(0.05)}$	672.56	875.22	0.072
CV(%)	7.03	4.98	5.22

4.5.5 Net return

The highest net return recorded for IC_6 (BDT 179350) followed by IC_5 (BDT 168650), IC_4 (BDT 151260) and then IC_3 (145550), while the lowest net return cost was recorded from IC_1 (BDT 123450) and then IC_2 (BDT 134870) for the management of nursery pests (Table 15). The findings indicate that combination of different types of insecticides give the highest net return for the nursery owners.

4.5.6 Benefit cost ratio (BCR)

The highest BCR was recorded for IC_6 (3.01) followed by IC_5 (2.89), IC_4 (2.62) and then IC_3 (2.59), while the lowest BCR was recorded from IC_1 (2.41) and then IC_2 (2.43) for the management of nursery pests (Table 15). The findings indicate that combination of different types of insecticides give the BCR also for the nursery owners.

4.5.7 Number of insects/seedlings

Number of insects/seedlings was recorded from infested seedlings/saplings and different insect species like as thrips, hairy caterpillar, aphid, stem borer, jassid, white fly, green bug, leaf miner and stem fly was recorded. The highest number of the recorded insects was attained from IC_1, whereas the lowest number was observed from IC_6 for all the recorded species (Table 16). Data revealed that combination of different insecticide was more effective than the others.

Table 16. Chemical used by the farmers' for nursery pest management their effects on insects abundance of nursery

Insecticide combinations	Number of insects/seedling								
	Thrips	Hairy caterpillar	Aphid	Stem borer	Jassid	White fly	Green bug	Leaf miner	Stem fly
IC_1	2.85 a	2.67 a	4.22 a	1.67 a	2.22 a	1.67 a	4.23 a	1.67 a	2.33 a
IC_2	1.67 b	2.52 bc	3.50 b	1.44 b	1.78 b	1.42 b	3.89 b	1.22 b	1.89 b
IC_3	1.22 c	2.41 c	3.12 c	1.22 c	1.54 c	1.11 c	3.54 c	0.00 c	1.56 c
IC_4	0.00 d	1.22 d	2.67 d	0.00 d	1.41 c	0.00 d	3.13 d	0.00 c	1.22 d
IC_5	0.00 d	0.00 e	2.25 e	0.00 d	1.22 d	0.00 d	2.67 e	0.00 c	0.00 e
IC_6	0.00 d	0.00 e	1.22 f	0.00 d	0.00 e	0.00 d	1.56 f	0.00 c	0.00 e
$LSD_{(0.05)}$	0.251	0.173	0.262	0.137	0.178	0.127	0.281	0.109	0.212
CV(%)	4.09	5.66	3.89	6.01	5.33	4.90	6.34	4.81	5.23

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APPENDICES

Appendix I. General information of different nursery

#	Name of nursery	Location	Year of establishment	Total plant species
1.	Asik Nursery	Narayangonj	1990	1245
2.	Green Orchidant Cactus Nursery	Shere-E Bangla Nagar	1995	890
3.	Krishibid Upakaran Nursery	Shere-E Bangla Nagar	1995	2342
4.	Astana Nursery	Narayangonj	2007	1289
5.	Forkan Nursery	Shere-E Bangla Nagar	2005	1167
6.	Ananda Nursery	Shere-E Bangla Nagar	2012	1870
7.	Barisal Nursery	Savar	2012	1207
8.	Faisal Nursery	Savar	2002	905
9.	Green Polli Nursery	Savar	1994	1356
10.	Mayer Doa Nursery	Savar	2007	1120
11.	Rongdhonu Nursery	Savar	2006	908
12.	Lalgolap Nursery	Savar	2005	1578
13.	Rasheda K Nursery	Savar	2002	2345
14.	Hotarse Nursery	Savar	2002	2470
15.	Adorshobon Nursery	Shere-E Bangla Nagar	1993	1259
16.	Mahabub Nursery	Narayangonj	2007	789
17.	Ajka Nursery	Narayangonj	2007	1478
18.	B.L. Sobuj Nursery	Narayangonj	1994	1245
19.	Popy Nursery	Narayangonj	2007	1178
20.	Faridpur Nursery	Shere-E Bangla Nagar	2007	980
21.	Kollpona Nursery	Savar	2007	1324
22.	Shorif Nursery	Narayangonj	1999	1125
23.	Kisorgonj Nursery	Savar	2006	1657
24.	Rakib Nursery	Narayangonj	1994	1534
25.	Sonali Nursery	Savar	2006	1267
26.	Sohag Nursery	Shere	2005	1089
27.	Noakhali Herbal Nursery	Shere	2005	903
28.	Liton Nursery	Shere	2010	945
29.	Jalokathi Nursery	Shere	2002	1123
30	Sonar Bangla Nursery	Shere	2008	2314

Appendix II. An interview schedule

DEPARTMENT OF ENTOMOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA 1207

An interview schedule

Serial No. :----------

Name of the respondent **:** **----------**

Location of the Nursery **:** **----------**

Year of establishment **:** **----------**

Number of plant species **:** **----------**

Please answer the following questions. Provided information will be kept confidential and will be used only for research purpose.

1. Land holding status

Mention your nursery ownership status (give tick mark against appropriate answer)

a) Own land ……... ( )

b) Leased in ownership …….. ( )

c) Shared ownership…..…….. ( )

2. Training exposure status

Mention your training exposure status (give tick mark against appropriate answer)

a) Received pest control training ……... ( )

b) Didn't received pest control training…….. ( )

3. Mention the duration of training that you received

a) Received training for …….. Days

4. Age

How old are you? …….. Years

5. Level of education

Mention your educational qualification (give tick mark against appropriate answer)

a) Do not know reading and Writing……..( )

b) Can sign only …….. ( )

c) Read upto class …..……...

6. Duration of involvement in nursery business

a) Please mention the age of your nursery? …….. Years

7. Please mention the seedling infestation level of nursery

Categories	No. of species
No infestation (0% infested plant)	
Low infestation (1-4% infested plant)	
Mild infestation (5-10% infested plant)	
Moderate infestation (11-30% infested plant)	
High infestation (31-50% infested plant)	
Severe infestation (above 50% infested plant)	

8. Please mention species wise seedlings/saplings infestation in your nursery

Crop species	Level of infested plant (%)					
	No infestation (0% infested plant)	Low infestation (1-4% infested plant)	Mild infestation (5-10% infested plant)	Moderate infestation (11-30% infested plant)	High infestation (31-50% infested plant)	Severe infestation (above 50% infested plant)
Mango						
Litchi						
Guava						
Jujube						
Pomegranate						
Malta						
Lemon						
Jambura						
Hog plum						
Sapota						
Papaya						
Eggplant						
Chili						
Rose						
Marigold						
Beli						

9. Please mention species wise major insect pests in different major plant species in their nursery

Crop species	Major insect pests (%)								
	Thrips	Hairy catterpillar	Aphid	Stem borer	Jassid	White fly	Green bug	Leaf minor	Stem fly
Mango									
Litchi									
Guava									
Jujube									
Pomegranate									
Malta									
Lemon									
Jambura									
Hog plum									
Sapota									
Papaya									
Eggplant									
Chili									
Rose									
Marigold									
Beli									

10. Please mention plant species wise control measure for controlling major insect pests in your nursery

Crop species	Different control measures					
	Chemical	Mechanical	Cultural	Field sanitation	Others-1	Others-2
Mango						
Litchi						
Guava						
Jujube						
Pomegranate						
Malta						
Lemon						
Jambura						
Hog plum						
Sapota						
Papaya						
Eggplant						
Chili						
Rose						
Marigold						
Beli						

11. Please mention plant species wise insecticides that you used in controlling major insect pests in your nursery

Crop species	Different control measures							
	Ripcord	Mancozeb	Dithane	Sevin	Bavistin	Simcaf	Cartap	Others
Mango								
Litchi								
Guava								
Jujube								
Pomegranate								
Malta								
Lemon								
Jambura								
Hog plum								
Sapota								
Papaya								
Eggplant								
Chili								
Rose								
Marigold								
Beli								

Thank you for giving your valuable time.

Date: **Signature of the Interviewer**

CHAPTER V

SUMMARY AND CONCLUSION

Thirty nursery of greater Dhaka district were selected for conducting the study. As a part of survey, total of 30 nursery owners were interviewed and make a clear observation through a questionnaire survey during the period from November 2013 to May 2014. Objective-oriented, structured questionnaires were used to identify socio-economic status of the nursery owners, intensity of infestation in different seedlings, major insect pests in nursery and their proportion for specific seedlings, species wise management practices and use of different insecticides for managing these insect pests for specific seedlings or saplings species were surveyed through a semi structured questionnaire.

In case of different interrelated characteristics of the nursery owners, among the respondent the highest (83.33%) nursery owners have own land, where as 13.33% have leased in ownership and only 3.33% nursery owner were shared ownership of their nursery land. The highest (96.96%) nursery owners received training on pest management only 3.33% didn't received any training on pest management. Among the respondent the highest (56.67%) nursery owners received low level training on pest management only 13.33% received high level training on pest management. Among the respondent the highest (53.33%) nursery owners were middle aged, 40.00% were young aged and only 6.67 percent were old aged. Among the respondent the highest (63.33%) nursery owners were educated at secondary level, 16.67% were above secondary level, 13.33% in primary level educated and only 6.67% can sign only. Among the respondent the highest (56.67%) nursery owners have moderate time involvement with nursery business, 26.67% have shortest time involvement and 16.67% have involvement for long time in nursery business.

Among the nursery the highest around 50.00% have low level infestation of nursery seedlings or saplings followed by 26.67% nursery in mid infestation level

and 3.33% nursery high and sever level infestation of seedlings and saplings. Different insects was recorded from infested seedlings/saplings and the species are thrips, hairy caterpillar, aphid, stem borer, jassid, white fly, green bug, leaf minor and stem fly was recorded. Nursery owners used different insecticides mainly Ripcord, Mancozeb, Dithane, Sevin, Bavistin, Simcaf, Cartap Endofil and used for controlling different insects .

The nursery owner's practices (NPs) for nursery pest management as calculated and analyzed all of 30 sample nursery together. Accordingly, the study reveals a total of 5 NPs for nursery pest management, which were, NP_1 (Chemical), NP_2 (Chemical, Mechanical), NP_3 (Chemical, Mechanical, Cultural), NP_4 (Chemical, Mechanical, Field sanitation) and Chemical, NP_5 (Mechanical, Cultural, Field sanitation). The nursery owners (43.33%) practicing NP_1 and the lowest nursery owners (6.67%) practicing NP_5. The highest seedling infestation was recorded from NP_1 (40.00%), whereas the lowest sapling infestation was observed from NP_5 (6.67%) followed by NP_4 (10.00%). The highest sapling infestation was recorded from NP_1 (36.67%) followed by NP_2 (26.67%) and NP_3 (23.33%), while the lowest seedling infestation was observed from NP_5 (3.33%) followed by NP_4 (10.00%) for the management of nursery pests. The highest production cost was calculated from NP_5 (BDT 45255) while the lowest production cost was observed from NP_1 (BDT 42455). The highest net return was found from NP_5 (BDT 161240), while the lowest net return was observed from NP_1 (BDT 123250). The highest BCR was calculated from NP_5 (3.56), while the lowest BCR was observed from NP_1 (2.90) followed by NP_2 (3.11) for the management of nursery pests. Number of insects/seedlings was recorded from infested seedlings/saplings and different insect species like as thrips, hairy caterpillar, aphid, stem borer, jassid, white fly, green bug, leaf miner and stem fly was recorded. The highest number of the recorded insects was attained from NP_1, whereas the lowest number was observed from NP_5 for all the recorded species.

The insecticides combination (ICs) for nursery pest management as reported by the entire 30 nursery together was primarily into different group. Accordingly, the study reveals a total of 6 ICs for nursery pest management, which may be designated as IC_1 (Ripcord), IC_2 (Ripcord + Mancozeb), IC_3 (Ripcord + Mancozeb + Bavistin) IC_4 (Ripcord + Mancozeb + Cartap) IC_5 (Mancozeb + Dithane + Sevin and IC_6 (Mancozeb + Simcaf + Endofil). The nursery owners practicing the highest (46.67%) for IC_1 followed by IC_2 (23.33%), IC_3 (13.33%) and IC_4 (10.00), whereas the lowest nursery owners (3.33%) practicing IC_5 and IC_6 for the management of nursery pests. The highest seedling infestation was recorded for IC_1 (43.33%), whereas the lowest seedling infestation was recorded from IC_6 (3.33%) and IC_5 (6.67%) for the management of nursery pests. The highest sapling infestation was recorded for IC_1 (53.33%), whereas the lowest sapling infestation was recorded from IC_6 (3.33%) and IC_5 (3.33%) for the management of nursery pests. The highest production cost recorded for IC_6 (BDT 59675), while the lowest production cost was recorded from IC_1 (BDT 51230) and then IC_2 (BDT 55450) for the management of nursery pests. The highest net return recorded for IC_6 (BDT 179350), while the lowest net return cost was recorded from IC_1 (BDT 123450) and then IC_2 (BDT 134870) for the management of nursery pests. The highest BCR was recorded for IC_6 (3.01), while the lowest BCR was recorded from IC_1 (2.41) and then IC_2 (2.43) for the management of nursery pests. Number of insects/seedlings was recorded from infested seedlings/saplings and different insect species like as thrips, hairy caterpillar, aphid, stem borer, jassid, white fly, green bug, leaf miner and stem fly was recorded. The highest number of the recorded insects was attained from IC_1, whereas the lowest number was observed from IC_6 for all the recorded species.

Conclusion

From the observed findings it may be concluded that:

- Among the nursery owner's practices chemical, mechanical, cultural and field sanitation (NP_5) were suitable in terms of insect pests control and benefit cost ratio (BCR);
- Among the insecticides combination (ICs) the Mancozeb + Simcaf + Endofil (IC_6) was suitable in terms of insect control and benefit cost ratio (BCR).

Recommendation

Based on the findings it may be recommended that-

- For the highest benefit from nursery business IPM practices would be more effective in controlling insect pests of nursery seedlings/saplings and also attaining highest benefit;
- Combination of different pesticides as chemical control would be more appropriate for management of nursery insect pests;
- For final recommendation more nursery owners need to be included in the survey system.