THE EFFECT OF EXTRACTS OF NEEM SEED ON SURVIVAL AND INFESTATION OF *THRIPS TABACI* ON ONIONS

BY

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ABSTRACT

Field and laboratory studies were conducted at Madiira Research Farm, Arusha to investigate the effectiveness of extracts of neem seeds for management of onion thrips, *Thrips tabaci* on onions. The efficacy and performance of extracts from Neem seeds, *Azadirachta indica* was compared with that of Fenitrothion, a commonly used standard insecticide. Neem extracts at concentrations of 0.8% and 1.0% AZ gave good protection against *T. tabaci* under field condition. A significant decline in population density (P = 0.05) of onion thrips was observed among treatments. Fewer thrips larvae and adults were recorded on treated plants than on control. However, the effectiveness and performance of extracts of neem seed varied with concentration and method of application. Alcohol extracts (0.8%) and aqueous extracts (1.0%) were more effective in lowering the number of *T. tabaci*. These levels of concentration compared favourably with fenitrothion. Significant differences (P=0.05) in onion yields were generally observed among treatments. Onions treated with extracts of neem seed gave higher yield than the control. The yields were not significantly different from fenitrothion treated crop. Neem seed extracts, even at the low concentration of 0.4 and 0.5%, resulted into significant mortality and ovipositional deterrence of thrips, but were less effective as repellents. Mortality and repellence increased with time and concentrations. At concentrations of 0.4 and 0.5% more thrips were found dead and strayed off from treated leaves. No mortality and repellence occurred in the control leaves. Onion leaves treated with the standard insecticide, fenitrothion, resulted to high death and repellence of thrips at 24 and 48 hours post treatment. The use of neem extracts proved to be effective in

providing good protection of onions against *T. tabaci*. Neem seed extracts have shown good potential for management of onion thrips on onions due to low cost, effectiveness, safety, availability and their easiness to prepare and use.

DECLARATION

I John Bosco Haule do hereby declare for Senate to Sokoine University of Agriculture that this dissertation has not been submitted for degree award in any other University.

Signed.....JBHaule..........................

Date...20. 8. 2023..............................

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DEDICATION

This dissertation is dedicated to my wife and parents whose efforts and encouragement managed to make me what I am.

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ABBREVIATIONS AND SYMBOLS

%	=	Percentage
a.i.	=	active ingredient
AZ	=	Azadirachtin
DAT	=	Days After Transplanting
DF	=	Degree of freedom
DMRT	=	Duncan's Multiple Range Test
FAO	=	Food and Agriculture Organization
g	=	gram
Ha	=	hectare
Hrs	=	hours
IPM	=	Integrated Pest Management
kg	=	Kilogram
L	=	liter
m	=	metre
mg	=	milligram
SE	=	Standard Error

CHAPTER ONE

1.0 INTRODUCTON

Onion (*Allium cepa*) (L) is one of the most important vegetable crops and is characterized by pungent alliaceous compounds. Most families consume them in a rather small quantity primarily as a seasoning for a wide variety of dishes. The leading onion producing countries in order of importance are the USA, Japan, Spain, Romania, Italy Mexico and Turkey (Edmond *et al,* 1977). In Tanzania onions are produced by, smallholder farmers under extensive cultural practices. Important producing areas are Iringa, Singida, Morogoro, Arusha and Mbeya. Produce from smallholder farmers is usually sold locally. According to the FAO, the average area under onion production in Tanzania is about 18,000 hectares/year (FAO, 2000). For the past 10 years (1990-2000), the average annual mean yield was 54,000 metric tones (Table 1) on hectare.

Despite of onion's good yield potential, typical yields in Africa and Tanzania in particular are low (FAO, 2000) due to poor crop husbandry, disease outbreaks and damage caused by insect pests. Like other vegetable crops, onions are often attacked most seriously by arthropod pests (Bhangdale and Joi,1983). The reasons are obvious, onions are grown mostly as intensive crops with considerable input such as fertilizer, irrigation water, etc and often continuously in limited area and with narrow crop rotation. Thus, insects find optimum conditions to develop high populations (Stoll, 1987). Because of susceptibility of onions to insects, onion growers tend to apply chemicals for their protection.

The most destructive and damaging pest of onions worldwide is the onion thrips, *T. tabaci*. It is ranked as a number one insect pest threatening onion production in Tanzania (FAO, 1993). It has been observed that continuous use of synthetic insecticides has led to more serious problems such as increased pesticides resistance and pest resurgence, farmer and consumer ill health, side effects to non-target organisms and environmental pollution and degradation (Matthews, 1985).

Because of these concerns, interest in the use of pest control agents derived from plant substances has increased (Arnason *et al.*, 1985., Stoll, 1988). Extracts of seed from the neem tree, *Azadirachta indica* Juss, have attracted considerable attention. Azadirachtin, the main active ingredient in neem exracts, has been demonstrated to have antifeedant and insect growth regulatory effects on insects (Ascher, 1981; Adhikary , 1981).

Table 1: Production of onion in Tanzania for the past 10 years (1990 - 2000).

Years.	Yield (metric tonnes/ha
1990	37,000
1991	49,300
1992	41,000
1993	52,500
1994	55,600
1995	53,000
1996	54,900
1997	58,400
1998	50,200
1999	56,400

Source: FAO (2000)

Significant increase of natural enemies has been observed after long term application of neem based insecticides which have led to reduction in synthetic insecticide application (Schmutterer, 1990). Therefore, the use of natural, plants derived materials like neem products remain the most practical and low cost inputs for smallholder farmers in Tanzania.

This study aimed at evaluating the effectiveness of extracts of neem seed against *T.tabaci*, on onions. The broad objective of the s tudy was to investigate the effect of neem seed extract treatments on infestation dynamics of *T. tabaci* on onions.

The specific objectives were to:

(i) Compare the efficacy of different concentrations of neem exracts with that of the synthetic organophosphate, Fenitrothion.

(ii) Establish an effective concentration of neem extracts which will control thrips.

(iii) Evaluate the potential yield that can be obtained after single or repeated spraying with neem extracts.

(vi) Determine the levels of natural infestation in untreated crops

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Economic importance of onions

From the aspect of food value, onions (*Allium cepa*) are of little importance and it has been said by food experts that the purchases of onion pays mainly for the smell (FAO, 1993). In protective food, it contains a little vitamin C and B, and also traces of iron and calcium (Edmond *et al,* 1977). This fact, however, does not prevent its popularity with the cook or the general demand for this bulb vegetable. Onions are grown for a variety of purposes such as fresh shoots for green "salad" and as bulbs for consumption uncooked; consumption cooked, pickling, use in factory-made food, dehydration, seed production (Tindall, 1983).

2.1.1.Important pests of onions

Onions are attacked by numerous pests all over the world, both in the field and storage. Onion thrips, *T. tabaci* (L) are the most destructive and damaging insect pests of onions in the world. They are prevalent in many onion producing areas and cause considerable crop losses in terms of quality and quantity. Recent surveys have shown that many popular and economically important cultivars of onions are affected by onion thrips. The severity of thrips attack may vary from year to year depending largely upon climatic conditions, but it is usually greatest when rainfall is below and temperature is above normal (Ascher, 1993., Soni and Ellis, 1990).

2.1.2 Onions thrips

Onion thrips are distributed worldwide and are considered as important pests of onion.They also affect leek and garlic. However, onion cultivars vary in susceptibility to thrips damage. The feeding of *T. tabaci* and fouling of plant surfaces result in yield losses. The feeding imparts a silvery sheen and cause distortion during growth and reduction in photosynthetic area. Feaces deposited by *T. tabaci* near feeding sites provide a medium for fungus growth and may be disfiguring when the population is high. *T. tabaci* feeding on onion seedlings has been reported to result in infection by *Alternaria porri* which causes purple blotch disease (Bhangdale and Joi, 1983., Mc Kensi *et al*, 1993., Edelson *et al*, 1986 ., Simmonds *et al.*, 1990). In USA losses caused by onion thrips range between 25 – 50% (Ascher, 1981)

2.1.3 Biology of onion thrips

Female thrips lay about 80 eggs on the leaves of host plants. The female usually lays eggs on the tender tissue of protected inner leaves (Schmutterer and Ascher, 1984). The eggs develop through two larval stages to the pupae stage. All stages are similar, and are slender in shape but the larval stages are smaller and pale yellow or green whereas the adults are darker and have narrow hair fringed wings. The pupae fall to the ground and the adults act as the dispersal stage, the delicate insects being easily carried by wind. The duration of the life cycle decreases as temperature increases and at 30^0C it takes only 11 days from egg to adult. The insect can remain quiescent in the soil in the adult or the larval stages and may also survive the winter in the necks of bulbs (Mordue and Blackwell, 1993).

2.1.4 Host range

Onion thrips are the major pests of leek, onion, cowpea, tobacco, citrus, garlic etc. They feed on young leaves of host plants and this causes considerable loss both qualitatively and quantitatively (Schmutterer *et al,* 1981).

2.1.5 Crop damage and loss

Onions infested with thrips develop spotted appearance on leaves that turn into pale white blotches due to drainage of sap. Both larvae and adults cause injury. They feed by rasping the surface of the leaves and sucking the liberated juices. Damage is most severe when plants are water stressed in hot, dry weather. In these conditions, leaf expansion is slow and increase in thrips numbers is rapid (Schmutterer, 1988). Badly damaged foliage may give the entire field a silvery appearance, yields may be greatly reduced and the quality is impaired (Saxena, 1989).

2.1.6 Status of onion thrips

Onion thrips can cause great damage if no preventive measures have been taken to restrict the increasing population. Mote (1978) reported about 50% losses of onion crops due to thrips. Seed production and viability are also hampered due to attack of *T. tabaci* (Singh and Sirvastava, 1983).

2.1.7 Mechanism of dispersal

Adult thrips are about 1.0 – 1.2mm long and usually light brown in colour. They have two pairs of fringed wings and are able to fly considerable distances to onion fields from other host plants.

2.2 Management of onion thrips

Control of *T. tabaci* using synthetic insecticide does not give good practical results as the thrips seek sheltered foliage. They have also been reported to develop resistance against many conventional insecticides thus making control programs using synthetic pesticides unsuccessful and not economically justifiable. Therefore, alternative measures for thrips control are urgently needed.

Several strategies/tactics have been developed, tested and recommended for management of onion thrips. These strategies include:

(a) Cultural practices to reduce pest population, several cultural practices have been recommended. They include

(i) Ploughing to bury over-wintering thrips in soil to reduce the infection source in the following year/season.

(ii) Crop rotation reduces the opportunity for infection from thrips over wintering in the soil.

(b) Chemical control: Traditionally, chemical control has been the common and major means used to control economic population of *T. tabaci* in onions. The chemicals used extensively include Actellic 50EC, malathion, etc (Schmutterer, 1995, Jacobson, 1995) However, onion thrips have developed resistance to most conventional pesticides that have been used

(c) Biological control: This involves the use of insect predators such as ladybird beetles and larvae of psyllid flies to reduce population density of onion thrips. However, these approaches give good practical results when applied under controlled conditions (green houses) than under open field conditions.

(d) Botanicals (use of natural pesticides): Considerable efforts are being made world wide to find safer, biodegradable substitutes for the synthetic pesticides (Crombie, 1990). In recent years, studies have focused more towards selective biorational pesticides from plants such as *A. indica*, *Derris elliptica*, *Jatropha curcas* etc. Such plant-derived compounds are generally perceived to be safer than the synthetics (Pimentel *et al,* 1992., Sieber and Rembold, 1983).

The major benefit of botanicals is that, they provide a much simpler, convenient and more flexible management system for insect control and farmers accord such convenience the highest priority (Stoll, 1987). This convenient technology can also reduce synthetic insecticides usage and provide better insect control which collectively result in higher productivity and returns per given area.

Among these botanicals, Azadirachtin (AZ) a mixture of several structurally related tetranotriterpenoids isolated from the seeds of neem tree (*A. indica A Juss,* Meliaceae), has attracted the greatest attention in recent years and has been reviewed extensively (Schmutterer, 1995., Ermel and Schmutterer, 1986). The neem tree as a plant with medicinal and pesticides properties seems to be the most promising of all plants as a source of pesticides and eventually it may benefit every person on the planet (Schmutterer , 1990).

Specifically, insecticidal activity of neem has been noted against aphids (Grahn , 1989), Colorado potato beetles (Steets, 1976), Mexican bean beetle (Schmutterer *et al*, 1981) Diamond back moth (Coat, 1994). Neem also has shown activity against nematodes (Equnjobi and Afolami, 1976) and banana weevils (Saxena and Musabyiana, 1997).

The compound responsible for these activities is azadirachtin, a terpenoid that Butterworth and Morgan (1986) isolated from neem seed. Azadirachtin is generally believed to affect the neuro-secretory cells of insect's brain, disrupting both the synthesis and release of neuro hormones that regulate the titer of ecdysteroids and juvenile hormones (Rembold *et al*, 1984). This interferes endocrine regulated processes and development (Schmutterer, 1995).

2.3 Resistance of onion thrips to insecticides

Onion's thrips have developed resistance against several synthetic insecticides. Schmutterer (1990) reported that, onion thrips developed resistance to malathion fenthion , dicofol etc. The first serious and widespread failure in chemical control was the development of resistance to organophosphates. However, resistance of neem is possible but the development of resistance is slow and unstable (Schmutterer, 1995). Furthermore, onion growers in Tanzania cannot afford to buy synthetic insecticides used to control onion thrips. Therefore, the use of natural pesticides (botanicals) like neem products remain the most practical and low cost inputs for smallholder farmers in Tanzania.

2.4 Neem tree

The neem tree is a fast growing plant that usually reaches a height of 15-20m and under very favorable conditions up to approximately 35 – 40m. As a rule, it is an evergreen tree, but under extreme circumstances, such as extended dry periods, it may shed most or nearly all of its leaves.

2.4.1 Ecology of neem tree

The neem tree is famous for its drought resistance. Normally it thrives in areas with sub-arid to sub-humid conditions with an annual rainfall between 800 to 1200mm. It can also grow in regions with an annual rainfall below 400mm but in such cases it depends largely on ground water.

The neem tree can grow in many different types of soils, but it seems to develop best in well-drained, deep sandy soils. A soil pH value of between 2 – 7.0 seems to be best for this tree (Schmutterer and Ascher, 1984). The tree is typically a tropical/sub-tropical plant with an annual mean temperature between 2 1^0C and 32^0C. Neem trees can also tolerate high to very high temperatures. For example, in North East and Central Africa where the temperature can reach 50^0C during the summer months. However, temperatures below 4^0C and frost conditions may result into shedding of leaves and even death of plants. The tree can be found on plain and low – lying hilly land. It thrives at altitudes between 700 – 800m a.s.l. At high altitude (1000 – 1500m a.s.l) the tree grows slowly with low production of fruit (Schmutterer, 1995).

The neem tree normally begins bearing fruit after 3 – 5 years, becoming fully productive in 10 years and from then on can produce up to 50 – 60kgs of fruits annually (Schmuttererr, 1990)

2.5 Pesticidal effects of neem tree products

(i) Insecticidal effect

Neem oil and its emulsifiable concentrate formulations have been studied and found to contain insecticidal properties. For example, 0.1 and 0.2% emulsion from the EC formulation selectively killed aphids, *Rhopalosiphum maidis* and *Melanaphis saccharri* (Pillai and Ponniah, 1988). Schmutterer (1990) reported that neem products are effective against *Helicorvefazea boddie, Spodoptera frugiperda* and *Diatraea saceba.*

Neem seed extracts have also been reported to have insecticidal effects on rice thrips (Saxena 1987). In addition, neem products particularly neem seed kernel and neem oil have proved to effectively control nematodes and banana weevils, which are serious pests of banana in Kenya (Saxena and Musabyamana , 1997).

(ii) Antifeedant properties

The neem tree has long been known to be resistant to the attack of many insects. Steets (1976) after reviewing early Indian literature reported that extracts from neem seed deter feeding by larvae of sixteen insect species and adults of twelve insects in India.

(iii) Oviposition deterrence and ovicidal effects

Azadirachtin is an effective sterillant (Saxena, 1989)., Schmutterer, 1987). It has been observed that the females of some insects such as the Colorado potato beetle, *Leptinotarsa decemlineata,* can be sterilized after up-take of active materials. The neem products when applied on plant parts under laboratory condition repelled the females of cabbage webworm, *Spodoptera frugiperda*, and few eggs were laid on them (Schmutterer, 1995).

(iv) Metamorphosis and growth disruption

Neem derivatives cause morphogenetic effects and mortality in many insects. Schmutterer (1990) reported that treatment with aqueous or alcohol neem seed kernel extract has little or no influence on the eggs laid and emergence of the first instar. Mong and Sudderuddin (1978) reported that treatment of diamond back moth, *Plutella xylostella,* with neem extracts at concentrations of 5,000 and 10,000 ppm per litre of water, reduces the rate of instar emergence. Laurense (1993) reported reduction of pupation and adult emergence of European corn borers, *Ostrinia nubilalis,* raised on artificial medium with neem at concentration of 0.1ppm

(v) Fecundity and egg sterility

Azadirachtin affects vitellogenesis, the process in which maturing adult insects synthesize specific proteins, which are incorporated into oocytes leading to their maturity. Singh (1993) reported that cotton bugs, *Dysdercus koenigii,* injected with neem products resulted into 50% mortality. In most cases, no eggs were laid due to failure of vitellogenesis

2.5.1 Neem seed extracts as a natural insecticide

The neem tree has been known for a long time for its medicinal and pesticidal properties. Intensive studies on products of the neem tree have indicated that many parts of the tree can produce materials for pest control (Jacobson, 1995., Attri, 1975., Ascher, 1992). Besides being environmentally friendly, neem based pesticides have the advantage of controlling a wide range of pests, an ideal pesticide for horticultural crops like onions (Isman *et al.,* 1991). Neem products have proved to be effective against important pests of horticultural crops such as black bean aphid, cowpea thrips, cabbage aphids, diamond back moth, leaf miners, caterpillars and root-knot nematodes (Schmutterer, 1995).

2.5.2 Importance of botanicals pesticides

(i) The botanicals have several merits including:

(ii) Environmentally friendly

(iii) No toxic residues are left after their application.

(iv) Economically justified (less expensive).

(v) They are safe to human beings and domestic animals

Generally, the use of botanical materials as natural pesticides that are relatively harmless to natural enemies could increase the effectiveness of natural predation (Coat, 1994)

2.5.3 The potential use of neem products in IPM programs

It has been observed that pesticides alone do not lead to sustainable pest management in agriculture. The cost of chemicals and their longterm deleterious effects to the environment and human health deter their continued use inspite of earlier spectacular success (Schmutterer, 1995). Maximizing pest control and crop production through the excessive and improper use of synthetic insecticides has shadowed environmental concerns but this must not continue in the future.

CHAPTER THREE

3.0 MATERIALS AND METHODS

Field and laboratory experiments were conducted at Tengeru Horticultural Research Farm, Arusha, to investigate the efficacy of extracts of neem seeds against *T. tabaci* on onions. Fenitrothion, a synthetic insecticide was used for comparison.

3.1.Experimental site

The trial was carried out at Madiira Research Farm near Tengeru. The farm is at an altitude of 1260m a.s.l.

3.1.1 Land preparation and plot size

The land was ploughed and harrowed, followed by sunken beds construction. Plot size used was 221m^2 (gross) with harvesting area (net plot) of 72m^2. To avoid inter-plot drift of chemicals during spraying, the plots were located 90cm apart.

3.1.2 Seed sowing and transplanting

Onion seeds variety "Bombay Red" was used in the experiment. Seeds were sown in a nursery bed and transplanted after 4 weeks when they reached pencil thickness or 20cm high. Seedlings were transplanted in the field at spacing of 10 x 15cm, giving a total of 60 plants per plot

3.1.3 Manures & Fertilizers

A well-decomposed farm yard manure was incorporated in each plot at rate of 20 tons /ha before transplanting. At transplanting, each plot received 1.5kg NPK. Top dressing with urea was done two weeks after transplanting at rate of 2 kg per plot.

3.1.4 Watering and weeding

Watering was done using furrow irrigation method except when it rained. The irrigation interval adopted in this trial was twice per week depending on weather conditions. At least two weedings /month were carried out manually

3.1.5 Disease control

Plants were sprayed with a fungicide to control onion diseases like purple blotch (*Alternaria porri*), powdery mildew etc. The spraying was done at weekly intervals using a knapsack sprayer.

3.2 Experimental design and Treatments

The trial was a Randomized Complete Block Design (RCBD) with 6 treatments and 4 replications. The treatments were as follows:

(i). 0.4% aqueous extract

(ii). 0.6% aqueous extract

(iii). 0.8% alcohol extract

(iv). 1.0% aqueous extract

(v). Fenitrothion 800g a.i./ha

(vi). Control

3.2.1 Preparation of different concentrations of neem extracts

Fresh neem seeds collected from ripe fruits were cleaned and dried in shade. The seeds were washed to remove the flesh and sun dried for 14 days. The outer skin was removed from the dry seeds and the kernels were pounded in a large mortar and pestle until a paste was formed (Stoll, 1995). One kg of fresh paste was dissolved in one liter of water and stirred repeatedly and soaked for 24 hours. The suspension was then sieved using a clean piece of cloth to form a stock solution of neem extracts. The stock solution was further diluted to provide a range of concentrations for use in the field and laboratory studies.

3.2.2 Spraying of chemicals

Treatments were applied at weekly intervals starting at 14, 21, 28, 35 and 42 days after transplanting. Spraying of chemicals was done early in the morning using a knapsack sprayer. Neem seed extracts were applied at dosage rates of 40, 60, 80 and 100g/litre of water. Control plots were sprayed with water

3.2.3 Population densities of onion thrips

Numbers of thrips larvae and adults on each plant were counted and recorded two days after treatment. Counting of thrips was done early in the morning. Sampling of thrips was done using hand held yellow wooden paddles, smeared with a thin coating of coconut oil. Thrips were sampled from twenty plants picked randomly from each plot. At maturity, dry bulbs from each plot were harvested, weighed and recorded.

3.3 Laboratory experiment

The laboratory bioassays consisted of five levels of neem exract concentrations (0.1, 0.2, 0.3, 0.4 and 0.5%). Fenitrothion 800g a. i/ha was used as a standard insecticide.

3.3.1 Preparation of different concentrations of NSE's

The different concentrations of extracts of neem seeds were prepared by dissolving 0.1, 0.2, 0.3, 0.4 and 0.5 gm of the paste in 10 milliliters of water. The suspension was then sieved using a clean piece of cloth to yield 10% aqueous neem seed extracts.

3.3.2 Rearing of *T. tabaci*

Adult females of onion thrips found on young tender leaves in the field were collected for laboratory bioassays. Rearing of onion thrips was done under controlled conditions (Ascher, 1981). Fifteen females and five male adult insects were introduced to a 1litre jar containing fresh leaves of onions. The opening of the jar was covered securely with a piece of cloth with a small access hole plugged with cotton. The thrips were maintained in a colony without introduction of additional field collected insects. Standard rearing procedures were followed. The temperature and relative humidity were maintained at 25 $\pm 2^{o}$ C and 60±5% RH, respectively.

3.3.3 Bioassay procedures

The biossay procedures followed a method described by Ascher (1981) The laboratory experiment involved testing of extracts of neem seeds against *T. tabaci* by exposure to treated onion leaves. Onion leaves, 10cm in length were dipped in various concentrations of neem seed extracts (1.0%, 0.2%, 0.3%, 0.4% and 0.5%) and Fenitrothion 800 g a. i/ha for 15 seconds and left to air dry for 1 hour. Treatments were arranged in complete randomized design with 7 treatments replicated 3 times. After air drying, the leaves were placed in Munger cells and thirty adult females and five adult males, 5 – 7 days old, were introduced in the test arena.

The onion thrips were anaesthetized with CO_2 for 30 minutes before being introduced into Munger cells. Dead thrips (mortality) were counted after 12, 24 and 48 hours. Repelled insects were determined by counting the number of thrips that strayed off from onion leaves.

To test ovicidal activity on thrips, adult females were first placed on untreated leaves of onions in Munger cells for 24 hours. The leaves were then dipped in neem seed extracts for 15 seconds. Control leaves were dipped in water. After 48 hours, the leaves were examined under a stereomicroscope and the number of eggs produced was counted and recorded.

3.4 Data collection and analysis

3.4.1 Data collection

The following were recorded:

(i). Mean number of larval thrips/ plant during pre-treatment and post treatment starting from 13 DAT to 44 DAT.

(ii) Mean number of adult thrips/plant during pre-treatment and post treatment period starting from 13 DAT to 44 DAT.

(iii) Yield of onions from each treatment.

(iv) Mortality and repellence of *T. tabaci in* treated and untreated plots.

(v). Number of eggs laid by adult females at 48 hrs

(vi) Population density of larvae and adult thrips on each plot before and after treatment.

3.4.2 Data analysis

Analysis of variance was carried out, followed by means separation using Duncan Multiple Range Test (DMRT)

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1.1 Mean number of thrips larvae

Results of performance and efficacy of neem seed extracts (NSE's) in comparison with the standard insecticide, fenitrothion, are shown in Figs 1,2,3,4,5&6. The population densities of thrips larvae varied among treatments. The lowest numbers of larvae were recorded in plots treated with fenitrothion and neem seed extracts at higher concentrations. Control plots had the highest number of thrips larvae throughout the growing period of onions (Fig.1,2 &3) before treatment; there were no significant differences in numbers of larvae. Significantly ($p< 0.05$) fewer larvae were recorded at 37 DAT and 44 DAT in all treatments compared to the untreated control.

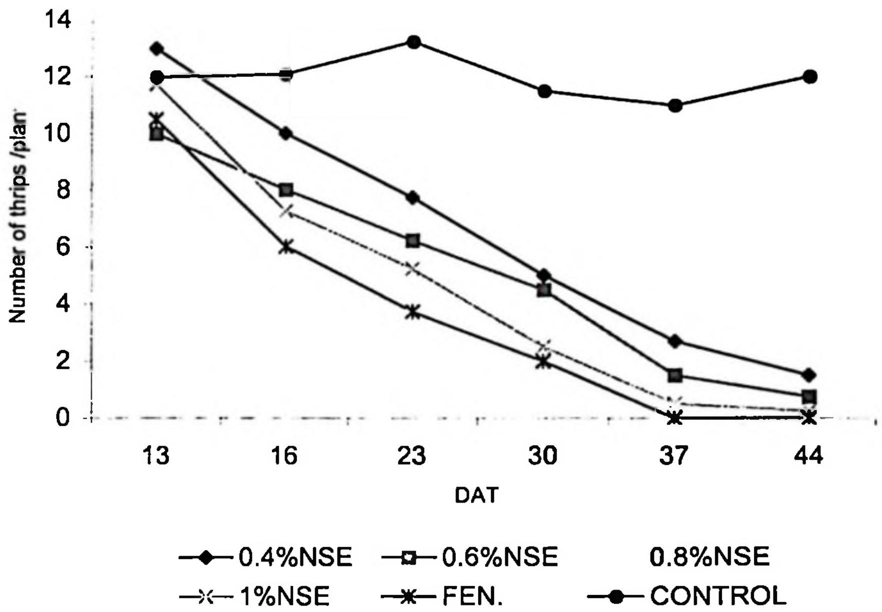

Figure 1: Population density of larval thrips on plants after treatment with neem seed extract or fenitrothion (FEN = Fenitrothion, NSE = Neem seed extract and DAT = Days after transplanting)

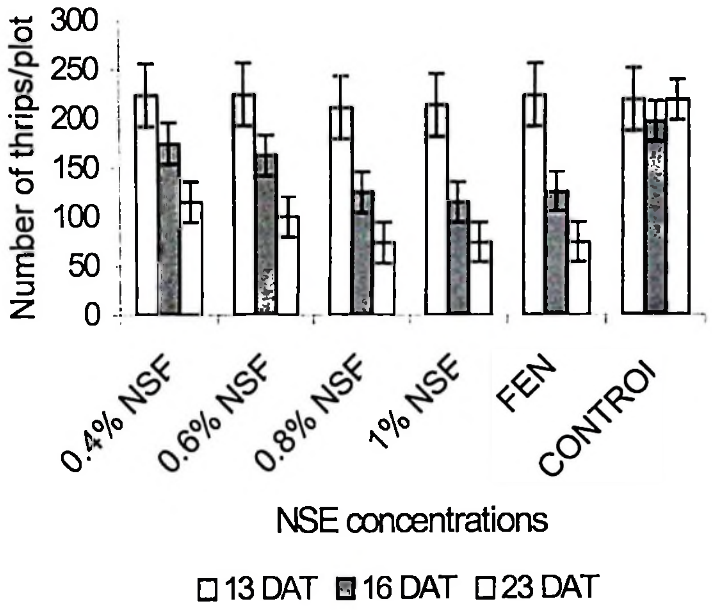

Figure 2: Population density of larval thrips (mean ± SE) on each plot after treatment with neem seed extract or fenitrothion.

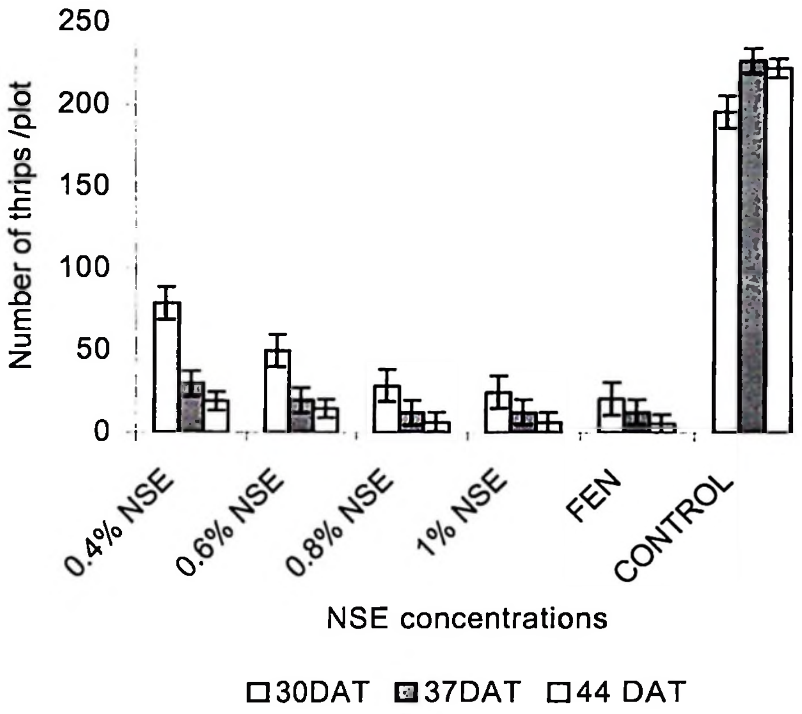

Figure 3: Population density of larval thrips (mean ± SE) on each plot after treatment with neem seed extract or fenitrothion.

4.1.2 Mean number of adult thrips

Fig 4, 5 & 6 show the number of adult thrips in the field for the entire growing period. Population densities of *T. tabaci* were significantly different ($P<0.05$) between treatments. The adult population was lower in plots sprayed with the insecticide than in untreated control. The efficacy of neem extracts in reducing population density of adult thrips differed considerably among the concentrations used and the duration after treatment.

The lowest numbers of adult thrips were recorded in treatment with neem extracts at concentrations of 0.8%, 1.0% and Fenitrothion. At 13 days after transplanting and before treatment, high numbers of adult thrips were recorded in all plots. From 16 DAT onwards, the population of *T. tabaci* in all treatments except in the control decreased significantly among treatments. Few adults however, were recorded in plots treated with Fenitrothion and neem seed extracts at 0.8 and 1.0% at 44 DAT.

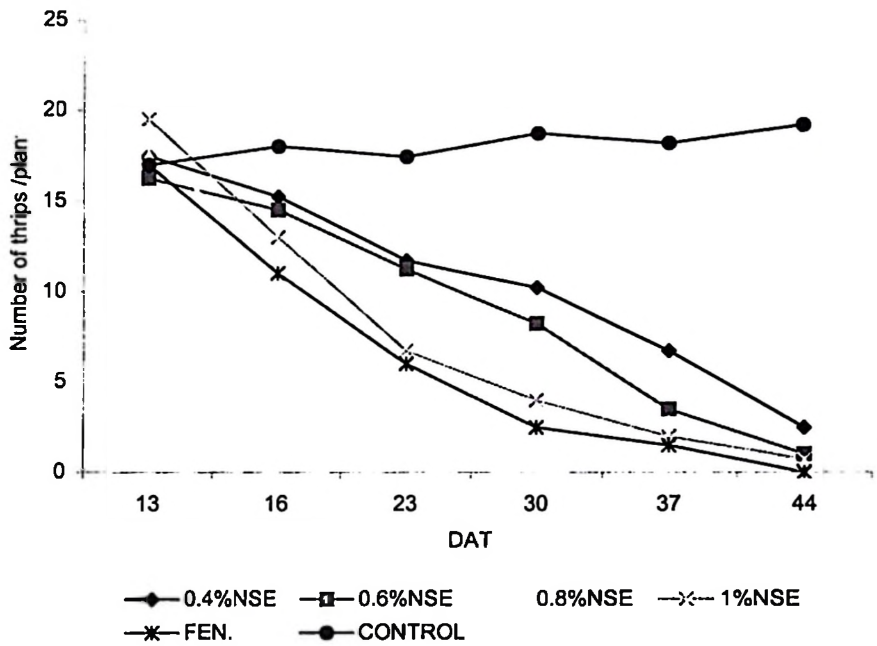

Figure 4 Population density of edult thrips on plants after treatment with neem seed extract or fenitroyhion (FEN = Fenitrothion, NSE = Neem seed extract and DAT = Days after transplanting).

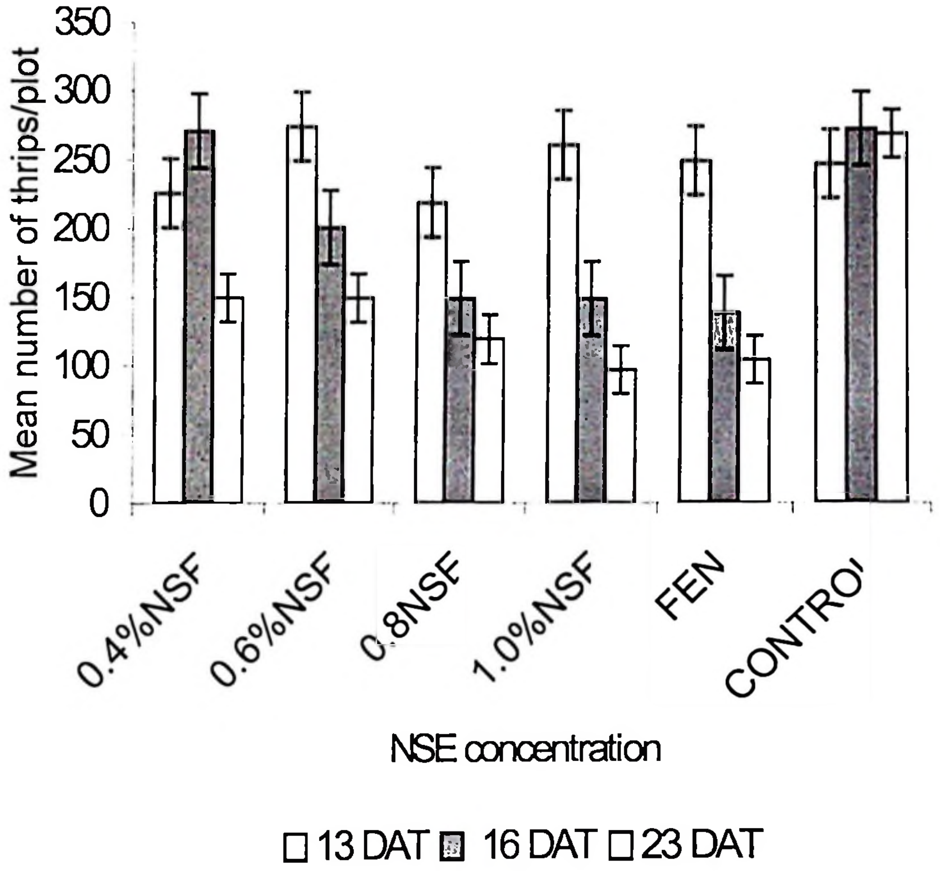

Figure 5: Population density of adult thrips on each plot (mean ± SE) after treatment with neem seed extract or Fenitrithion.

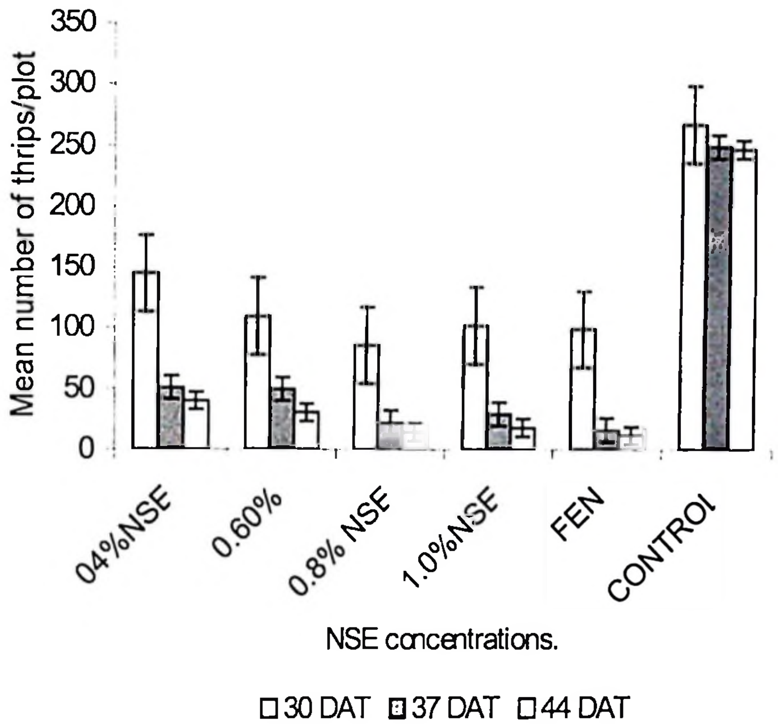

Figure 6: Population density of adult thrips t (mean ± SE) on plots after treatment with neem seed extract or fenitrothion.

These results show that extracts from neem seed *(Azadirachta indica)* had some insecticidal effects on *T. tabaci*. In general, the field results indicated that neem seed extracts reduced the number of larval and adult thrips.

Pillai and Ponniah (1988) used various neem seed extracts (5% and 10%) and neem oil (2%) and one synthetic insecticide, fenthion, against the rice thrips, *Stenchactothrips* *biformis*. The results indicated that there was a significant decrease of thrips population 2 days after application in all neem seed extracts. In general, the results of the present study have demostrated that neem seed extracts are quite effective against *T. tabaci*

4.1 Performance of extracts from neem seed against *T. tabaci*

The efficacy and performance of neem seed extracts used in this study varied with concentration and formulation used. In this study, it has been demonstrated that, a higher concentration of neem seed extracts was associated with greater reduction in the population density of *T. tabaci*. Neem extracts tested at concentration. of 0.8% and 1.0% were more effective than at concentrations of 0.4 and 0.6% in controlling onion thrips under field conditions. In order to increase their effectiveness against *T. tabaci* therefore, thorough coverage of spray on foliage should be carried out with an adequate amount of extracts to ensure a good contact of *T. tabaci* with the extracts on onions. Schmutterer (1990) reported that inadequate application of botanical extracts in field crops does not prevent insects from feeding.

The present study has indicated that there is a remarkable difference in effectiveness between water and alcohol extracts of neem seed. With exception of 1.0% aqueous neem extracts, all water extracts differed significantly from alcohol extracts in their effectiveness against *T. tabaci*. The population density of *T. tabaci* in the field decreased drastically in plots treated with 0.8% alcoholic extracts compared to the other neem treatments This study therefore shows that alcohol extracts are more effective against *T. tabaci* than water based extracts.

Alcohol extracts have been reported to be more concentrated because neem limonoids are highly soluble in alcohol solvents and less soluble in water (BOSTID, 1992). The current study indicates that none of the neem seed extracts protected the onion plants completely from infestation by *T. tabaci* but differences in effectiveness among the neem seed extracts were obvious.

These findings suggest that *A. indica* extracts will not provide complete protection of the crops from insect infestation. This is certainly due to environmental factors such as temperature, sunlight, relative humidity and rainfall, which are believed to reduce effectiveness of neem seed extracts. Also wind drift during application, inadequate coverage of spray on foliage, long spray intervals etc. reduce the effectiveness of the extracts.

Stoll (1995) reported that heavy rainfall a few hours after application of botanical extracts can wash them away from the plant surface and this reduces the effectiveness. In Nigeria, Raheja (1973) considered population of 5 thrips per plant as critical. The severity of thrips however, depends on prevailing weather conditions. Hot weather leads to severe damage. The results of the present study clearly show that the use of neem seed extracts especially at higher concentrations can reduce the pest population to the same level as the synthetic insecticide. Therefore, neem seed extracts and fenitrothion are capable of reducing the population of *T. tabaci* on onions to uneconomic levels. Schmutterer and Ascher (1984) showed a marked difference on their performance depending on stage of insect growth, insect species and weather conditions after insecticide application. Attri and Singh (1977) reported that activity of neem products against locusts in the field in India varied between batches of seed.

Table 2: Mean monthly Rainfall (mm), Temperature (°C) and Relative humidity (%) between September 2001 and March 2002 at Madira research farm in Arusha Region.

Month	Rainfall (mm)	Temperature (°C)	Relative humidity (%)
September	6.5	16.06	21.15
October	2	26.89	23.23
November	28	24.23	23.43
December	6	24.5	25.45
January	10	24.5	22.5
February	15	24.75	25.5
March	25	24.6	35

Table 2 shows the monthly distribution of rainfall, temperature and relative humidity at Madiira research farm (Arusha region). Weather conditions have an influence on incidence and severity of onion thrips. As temperature increases, population density also rises (October-February)

4. 3 Mean yield of onions

Onion yields differed significantly between treatments and control. (Table 3). Onions sprayed with Fenitrothion and neem seed extracts (0.8 and 1.0%) had higher yields than the other treatments. The untreated plots had relatively lower yields compared to the treated

Table 3: Yield of Onion in plots treated with Neem seed extract and fenitrothion

Treatment	Yield (kg/plot) (Mean ± S.E)
0.4%NSE	1.9 ± 0.1^{c}
0.6%NSE	2.2 ± 0.1^{c}
0.8%NSE	3.4 ± 0.2^{b}
1% NSE	3.9 ± 0.3^{a}
FEN	3.8 ± 0.3^{a}
Control	1.5 ± 0.1^{d}
Mean	2.804
CV %	8.052

Means followed by the same letter (s) within a columns are not significantly different (P=0.05) by DMRT.

CV = Coefficient of variation

S.E = Standard error

FEN = Fenitrothion

NSE = Neem seed extract

Although, some high yielding onion varieties have been developed for cultivation, the results of the present study have shown that thrips management is necessary to reduce yield loss in onion crop. Although synthetic insecticides are generally recommended for thrips control, their use and affordability by small-scale farmers in developing countries strapped for cash resources is limited.

The increased yield of onions treated with extracts of neem seeds can possibly be attributed to reduction in the number of *T. tabaci.*

4.4 Laboratory bioassays

4.4.1 Mortality of *T. tabaci*

Fig.7 shows the percent mortality of *T. tabaci* adults when exposed to neem extracts or Fenitrothion at 12, 24 and 48hrs post treatment.

Significant differences (P=0.05) in percent mortality of *T. tabaci* between treatments were observed at 12, 24 and 48 hours after treatment. The results show that that mortality of *T. tabaci* increased with increasing concentration (Fig.7). The neem seed extracts gave significantly higher mortality than the control. Percent mortality of thrips however, differed considerably among neem concentrations. At concentrations of 0.4 and 0.5%NSE more thrips were found dead than at concentrations below 0.3%.

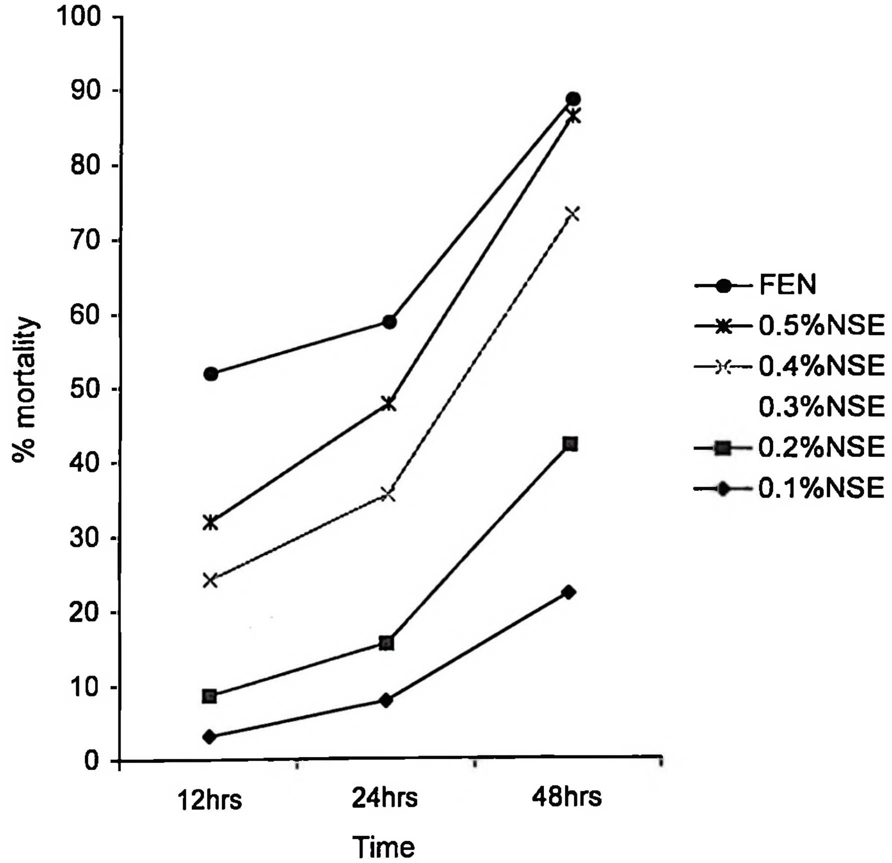

Figure 7: Cumulative percentage mortality of *T. tabaci* at different time intervals after treatment with neem seed extract or fenitrothion.

4.4.2 Repellence of *T. tabaci*

Fig.8 shows the repellent effect of neem extracts on thrips. Repellence of onion thrips increased with increasing concentration of NSE. There were significant differences (p=0.05) in the repellence of *T. tabaci* in all neem treatments. Higher concentrations (0.4 and 0.5% NSE) were associated with higher levels of repellence activity of onion thrips. No repellence activity was observed in the control leaves.

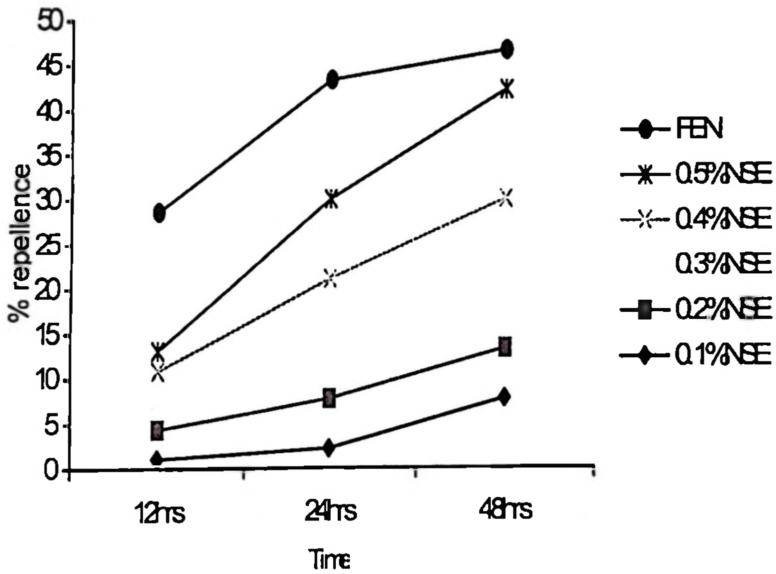

Figure 8: Cumulative percentage repellance of *T. tabaci* at different time intervals after treatment with neem seed extract or fenitrothion.

4.4.3 Number of eggs

The number of eggs laid by adult female thrips is shown in Table. 4.

There were no significant differences ($p < 0.05$) in the number of eggs laid on onion leaves treated with neem seed extracts and fenitrothion The number of eggs laid differed significantly between treated and untreated control. Higher numbers of eggs were laid on untreated than on treated onion leaves.

Table 4: Number of eggs laid by *T. tabaci* on onion leaves 48 hours after treatment.

Concentration (g/l)	Number of eggs (Mean± S.E)
10	3.3 ± 1.8^{b}
20	6.7 ± 2.0^{b}
30	1.7 ± 1.0^{b}
40	2.0 ± 1.2^{b}
50	4.3 ± 1.9^{b}
FEN	0.7 ± 0.1^{b}
Control	17.7 ± 3.0^{a}
CV %	41.48

Means followed by the same letter within a column are not significantly different ($P= 0.05$) by DMRT.

CV = Coefficient of variation

S.E = Standard error.

4.5. Laboratory evaluation

In the laboratory tests, neem seed extracts, even at concentration of 0.4% and 0.5%, significantly caused mortality/ repellence and ovipositional deterrence of *T. tabaci*. These results are consistent with the findings by Butterworth and Morgan (1986) who reported that, neem extracts at lower concentrations resulted into mortality and reduced the number of eggs laid by adult females on onion treated leaves.

The pesticidal effects of neem extracts on *T. tabaci* were obvious in this study. The ovipositional effects on *T. tabaci* are in agreement with Ascher (1992) who reported that females of *Frankliniella occidentalis* when allowed to oviposit 24 hours on seedlings treated with neem seed extracts resulted to significant reduction of fecundity even at concentrations of 0.5%AZ.

Extracts of neem had repellent effects against onion thrips. Also, the seed extracts reduced fecundity of onion thrips 48 hours post treatment, compared to eggs laid on control leaves. The efficacy of neem extracts was better under controlled conditions in the laboratory than in the field. Higher mortality was recorded in the laboratory where conditions were more stable than in the field..

The major components of neem, which have bioactivity, belong to a general class of natural products called tetraterpenes or limonoids. These have been demonstrated to block insect growth, affecting a range of insects. Azadirachtin, Salamin, melantirol and nimbin have been reported as most significant limonoids (BOSTID, 1992). Azadirachtin however, is the main active ingredient of neem extracts (Schmutterer and Ascher, 1984). It appears to cause 90 percent of the effects on most species. It does not kill insects immediately but instead, it both repels and disrupts their growth and reproduction. (Schmutterer, 1990). The results of the bioassays show that neem seed extracts are more effective as insecticides against *T. tabaci* but ineffective as repellents. Possibly, neem seed extracts at higher concentrations would repel thrips better. Reduced fecundity of adults and reduced growth and development of thrips larvae were possibly responsible for low thrips population density on onions.

The neem seed is a renewable natural resource with multiple uses. Its low or negligible cost for pest management could also be an advantage for farmers.

The use of neem extracts for onion thrips management has the added benefit of weak or inconsequential side effects on the pest's natural enemies and crop pollinators and other ecologically important non-target organisms (Schmutterer, 1990). This is now considered a prerequisite for successful integrated pest management.

The results obtained in the present study have demonstrated neem seed extracts can provide good protection against onions thrips. The extracts of neem seed proved to be equally effective as the synthetic insecticide in controlling the onion thrips and reducing field loss.

The use of neem products for pest control in onion gave varying results and must be viewed from different angles. Although good control of onion thrips has been reported by several researchers world wide, one can expect that neem products will be applied against thrips mainly at home gardens or in small fields in the near future since large fields require a considerable amounts of extracts, a demand which cannot be met by the growers in most developing countries at present.

A significant advantages to the use of neem seed extracts (NSE's) for management of *T. tabaci* would be reduced reliance on broad spectrum synthetic insecticides and in integrated pest management programs. Here, neem seed extracts can replace conventional insecticides to a certain extent.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 CONCLUSION

Neem seed extracts at concentration of 0.8% and 1.0% showed comparable performance to the standard insecticide, Fenitrothion, in lowering the population density of onion thrips.

The population densities of *T. tabaci* present before and after application of neem extracts were significantly different even at the lower concentration. However, under field conditions higher doses will be required to kill the onion thrips.

The present study shows that average yield differs significantly between treatments. Therefore, the use of neem extracts leads to reduction of thrips population and high yields are obtained.

5.2 RECOMMENDATIONS

The present study has revealed the differences in the performance and efficacy of NSE against *T. tabaci*. Therefore NSE can justifiably be recommended for use as cost-effective and safe biodegradable pesticide in management of onion thrips.

Fenitrothion, a systemic insecticide, can be used as the second alternative or can be used jointly with botanicals in integrated pest management programs.

More studies are required to investigate the potential of botanicals for use in IPM programs.

The use of neem based products should be highly encouraged for resource limited farmers since they are economical, readily available, safe to use and are relatively less active against natural enemies.

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APPENDICES

Appendix 1a: Analysis of variance of population density of thrips larvae at 16 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	19.50	6.50	1.25	0.5008
Treatment	5	75.00	15.00	2.89	
Error	15	78.00	5.20		
Corrected total	23	172.00			

Appendix 1b: Analysis of variance of population density of thrips larvae at 23 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	22.79	7.50	0.87	0.4169
Treatment	5	22.20	4.44	0.51	
Error	15	130.96	8.73		
Corrected total	23	175.96			

Appendix 1c: Analysis of variance of population density of thrips larvae at 30 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	4.46	1.49	0.23	0.3970
Treatment	5	35.38	7.08	1.10	
Error	15	95.79	6.39		
Corrected total	23	135.63			

Appendix 1d: Analysis of variance of population desity of thrips larvae at 37 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	4.13	1.38	0.27	0.3970
Treatment	5	51.21	10.24	0.98	
Error	15	77.63	5.18		
Corrected total	23	132.97			

Appendix 1e: Analysis of variance of population density of thrips larvae at 44 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	18.33	6.11	5.34	0.0105
Treatment	5	116.50	23.30	20.36	
Error	15	17.17	1.14		
Corrected total	23	152.00			

Appendix 2a: Analysis of variance of population density of thrips adult at 16 DAT .

Source	DF	SS	MS	F-value	P
Replication	3	11.17	3.72	0.19	0.3902
Treatment	5	68.83	13.77	0.71	
Error	15	289.83	19.32		
Corrected total	23	369.83			

Appendix 2b: 1Analysis of variance of population density of adult thrips at 23 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	35.46	11.82	1.31	0.3549
Treatment	5	54.21	10.84	1.20	
Error	15	135.29	9.02		
Corrected total	23	224.96			

Appendix 2c: Analysis of variance of population density of adult thrips at 30 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	56.33	18.78	2.91	0.0687
Treatment	5	60.33	12.07	1.87	
Error	15	96.67	6.44		
Corrected total	23	213.33			

Appendix 2d: Analysis of variance of population density of adult thrips at 37 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	56.46	18.82	2.95	0.0668
Treatment	5	40.71	8.14	1.28	
Error	15	95.79	6.39		
Corrected total	23	192.96			

Appendix 2e: Analysis of variance of population density of adult thrips 44 DAT.

Source	DF	SS	MS	F-value	P
Replication	3	13.83	4.61	1.17	0.0051
Treatment	5	105.50	21.10	5.35	
Error	15	59.17	3.94		
Corrected total	23	178.50			

Appendix 3: Analysis of variance of number of eggs laid by T. tabaci on onion leaves 48 hours after treatment.

Source	DF	SS	MS	F-value	P
Treatment	6	615.43	112.54	8.54	0.0045
Error	14	122.00	12.00		
Corrected total	20	737.43			

.0030

.0017

Appendix 4a: Analysis of variance of mortality and repellence data for onion thrips exposed to neem seed extract and fenitrothion 12 hours after treatment.

(i) Mortality

Source	DF	SS	MS	F-value	P
Treatment	6	2.16	0.36	.360.05	0.0030
Error	14	0.01	0.01		
Corrected total	20	2.17			

(ii) Repellence

Source	DF	SS	MS	F-value	P
Treatment	6	0.31	0.38	293.01	0.0017
Error	14	0.01	0.01		
Corrected total	20	0.32			

Appendix 4b: Analysis of variance of mortality and repellence data fenitrothion 24 hours after treatment.

(i) Mortality

Source	DF	SS	MS	F-value	P
Treatment	6	2.10	0.35	335.59	0.0019
Error	14	0.02	0.01		
Corrected total	20	2.12			

(ii) Repellence

Source	DF	SS	MS	F-value	P
Treatment	6	2.21	0.36	119.71	0.0004
Error	14	0.26	0.01		
Corrected total	20	2.47			

Appendix 4c: Analysis of variance of mortality and repellence data for onion thrips exposed to neem seed extract and fenitrothion 48 hours after treatment.

(i) Mortality

Source	DF	SS	MS	F-value	P
Treatment	6	1.82	0.30	209,09	0.0021
Error	14	0.02	0.01		
Corrected total	20				

(ii) Repellence

Source	DF	SS	MS	F-value	P
Treatment	6	2.39	0.40	337.02	0.0028
Error	14	0.02	0.01		
Corrected total	20	2.41			