EVALUATION OF CROPPING SYSTEMS AND PESTICIDES AS STRATEGIES FOR MANAGING FLOWER THRIPS IN SNAP BEANS IN MWEA-TEBERE, CENTRAL KENYA

BY

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A thesis Submitted to the University of Nairobi, School of Biological Sciences, in Partial Fulfilment of the requirements for the award of Degree of Master of Science in Agricultural Entomology

AUGUST 2008
DECLARATION

This thesis is my original work and has not been submitted for a degree award in any other university.

Signature……………………………..Date…………………………

Supervisors

We confirm that under our supervision, the candidate carried out the work in this thesis and we approve it for submission for examination.

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Signature…………………………………..Date…………………………
DEDICATION

To my wife;
   Mary,
   Sons;
   Isaac,
   David,
   John,
   Patrick,
for their support, patience and encouragement.
ACKNOWLEDGEMENTS

I appreciate our lord for giving me courage to undertake this study and pass my sincere thanks to the Ministry of Education Science and Technology for granting me study leave. My gratitude go to Dr G.H.N. Nyamasyo and Professor J.H. Nderitu, for guidance and willingness to discuss with me various technical aspects.

I acknowledge KARI National fibre research centre Mwea and especially Entomologist Mr. B.M. Ngari, Field technologist, Mr. P. Karichu, Ms. M. Muthoni and other staff who assisted in this study in one way or the other. I pay special tribute to Technical manager of Bayer East Africa, Mr. Robert Githaiga, for providing Calypso pesticide.

I wish to thank ASARECA (Association of Strengthening Agricultural Research in East and Central Africa) for financial support. Special tribute to Mr. J.A. Aura and other technical staff of the Department of Plant Science and Crop Protection, University of Nairobi for their technical support and encouragement.

This work could not have been completed without invaluable comments by Dr. P.N. Mwangi of Jomo Kenyatta University of Agriculture and Technology and all staff of Biometry Department College of Agriculture and Veterinary Science, University of Nairobi.

Finally, I wish to thank all my relatives and especially my mother Mary and my sisters and brothers for their prayers of comfort during the study.
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ABSTRACT

Field experiments were carried out in Mwea-Tebere, central Kenya with the objective of comparing the effectiveness of cropping systems and pesticides in suppressing flower thrips *Frankliniella occidentalis* Pergande and *Megalurothrips sjostedti* Trybom on Snap beans (*Phaseolus vulgaris* L) variety Samantha. The cropping systems treatments were Snap beans grown with maize (*Zea mays*) as margin crop, Snap beans grown with maize (*Zea mays*) as intercrop, untreated Snap beans or Snap beans sprayed with a pesticide Thiacloprid. The treatments were laid out in completely randomised design with four replicates. Flowers and pods were collected from ten randomly selected plants per plot for identifying and counting the number of thrips. The results indicate that there was significant difference (*P*<0.5) between the four treatments. The lowest number of *Megalurothrips sjostedti* and *Frankliniella occidentalis* adults thrips and larvae was recorded in those plots treated with *Z. mays* as intercrop, while the highest number was in the Snap bean sole plots (untreated) in both plantings. In addition, Snap bean plots treated with *Z. mays* as a margin crop had moderate number of thrips. Thiacloprid treated plots had the lowest number of *M. sjostedti* but the number of *F. occidentalis* was marginally affected by this pesticide in the two plantings. In general, *M. sjostedti* population was higher than that of *F. occidentalis* in both plantings. Snap bean plots treated with *Z. mays* as intercrop showed the highest percentage of marketable pods whereas the untreated plots (Snap bean sole) had the highest number of severely damaged pods, which are least marketable. Thrips natural enemies were high in plots treated with *Z. mays* as intercrop, margin crop and sole crop but least in the Thiacloprid treated plots.
Treatments for the pesticide experiment were Azadirachtin 0.06% A.I, Azadirachtin 0.15% A.I and Thiacloprid. The treatments were laid out in a Complete Randomized Design with four replicates. The pesticides were applied after the emergence of flowers and twice per week thereafter. Thrips infestations were assessed before and after every application of the pesticides. Ten flowers were picked from ten randomly selected plants per plot for identifying and counting the number of thrips. There was significant differences ($P<0.5$) between the four pesticides. The lowest number of *Megalurothrips sjostedti* and *Frankliniella occidentalis* adult thrips and their larvae was recorded on plots treated with Chloropyriphos and Azadirachtin 0.15% A.I in both plantings while the highest number was in the Snap beans sole plots (untreated). In addition Snap bean plots treated with Azadirachtin 0.06% A.I had moderate number of thrips The Thiacloprid treated plots had the lowest number of *M. sjostedti*, but the number of *F. occidentalis* was slightly affected by this pesticide in the two plantings. In general, the population of *M. sjostedti* was higher than that of *F. occidentalis* in both plantings. Snap bean plots treated with Chloropyriphos and Azadirachtin 0.15A.I showed the highest percentage of marketable pods whereas Azadirachtin 0.06% A.I had the highest number of severely damaged pods, which are least marketable. Thrips natural enemies were high in the plots treated with Azadirachtin 0.15% A.I, Thiacloprids and Azadirachtin 0.06% A.I, but least in Chloropyriphos treated plots. Overall, it can be deduced that smallholder farmers can manage flower thrips by intercropping (*Phaseolus vulgaris* L) Snap beans with maize (*Zea mays* L) or application of the pesticides, Chloropyriphos and Azadirachtin 0.15% A.I in their farms and reduce the use of synthetic pesticides which are expensive to the small holder farmer.
<table>
<thead>
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<tr>
<td>%</td>
<td>Percent</td>
</tr>
<tr>
<td>°C</td>
<td>Degrees Celsius</td>
</tr>
<tr>
<td>F-Test</td>
<td>Fisherman test</td>
</tr>
<tr>
<td>Ksh.</td>
<td>Kenya shilling</td>
</tr>
<tr>
<td>Africert</td>
<td>Horticultural Produce certifying body</td>
</tr>
<tr>
<td>A.I</td>
<td>Active ingredient</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>ASARECA</td>
<td>Association of strengthening Agricultural Research in East and Central Africa</td>
</tr>
<tr>
<td>BC</td>
<td>Margin crop</td>
</tr>
<tr>
<td>B.F.T</td>
<td>Bean flower thrips</td>
</tr>
<tr>
<td>C.A.N</td>
<td>Calcium Ammonium Nitrates</td>
</tr>
<tr>
<td>C.I.A.T</td>
<td>International Centre of Tropical Agriculture</td>
</tr>
<tr>
<td>CRD</td>
<td>Complete Randomised Design</td>
</tr>
<tr>
<td>CSNV</td>
<td>Chrysanthemum Stem Necrosis Virus</td>
</tr>
<tr>
<td>CT</td>
<td>Thiacloprids</td>
</tr>
<tr>
<td>EUROGAP</td>
<td>European Good Agriculture Practice</td>
</tr>
<tr>
<td>EC</td>
<td>Emulsion Concentrate</td>
</tr>
<tr>
<td>GTZ</td>
<td>German Technical Cooperation</td>
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<tr>
<td>Genstat</td>
<td>Statistical package</td>
</tr>
<tr>
<td>GRSV</td>
<td>Groundnut Ring Spot Virus</td>
</tr>
<tr>
<td>IC</td>
<td>Intercrop</td>
</tr>
<tr>
<td>I.C.I.P.E</td>
<td>International Centre for Insect Physiology and Ecology</td>
</tr>
<tr>
<td>IITA</td>
<td>International Institute of Tropical Agriculture</td>
</tr>
<tr>
<td>INSV</td>
<td>Impatient Necrotic Spot Virus</td>
</tr>
<tr>
<td>I.P.M</td>
<td>Integrated Pest Management</td>
</tr>
<tr>
<td>KARI</td>
<td>Kenya Agricultural Research Institute</td>
</tr>
<tr>
<td>KEPHIS</td>
<td>Kenya Plant Health Inspectorate Service</td>
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<tr>
<td>Kg</td>
<td>Kilogramme</td>
</tr>
<tr>
<td>L</td>
<td>Linnaneous</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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<tr>
<td>LSD</td>
<td>Least Statistical Difference</td>
</tr>
<tr>
<td>M</td>
<td>Metre</td>
</tr>
<tr>
<td>Macros</td>
<td>Macronutrient</td>
</tr>
<tr>
<td>M .L</td>
<td>Millilitre</td>
</tr>
<tr>
<td>M.C</td>
<td>Sole Crop</td>
</tr>
<tr>
<td>M.S</td>
<td>Megarulothrips sjostedti</td>
</tr>
<tr>
<td>NARL</td>
<td>National Agriculture Research Laboratories</td>
</tr>
<tr>
<td>NB</td>
<td>Nota Bene</td>
</tr>
<tr>
<td>NPK</td>
<td>Nitrogen Phosphorus Potassium</td>
</tr>
<tr>
<td>pH</td>
<td>Degree of acidity and alkalinity</td>
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<tr>
<td>pp</td>
<td>Page</td>
</tr>
<tr>
<td>SED</td>
<td>Statistical Error Difference</td>
</tr>
<tr>
<td>SGS</td>
<td>Horticultural Produce Certifying body</td>
</tr>
<tr>
<td>T.</td>
<td>Trybom</td>
</tr>
<tr>
<td>TCSV</td>
<td>Tomato Chlorotic spot virus</td>
</tr>
<tr>
<td>TSWV</td>
<td>Tomato Spotted Wilt Virus</td>
</tr>
<tr>
<td>WFT</td>
<td>Western Flower thrips</td>
</tr>
<tr>
<td>USA</td>
<td>United state Of America</td>
</tr>
<tr>
<td>Veritas</td>
<td>Horticultural produce certifying body</td>
</tr>
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</table>
CHAPTER 1

1.0 INTRODUCTION

Snap bean, (*Phaseolus vulgaris* L.) is a major export vegetable commodity in Kenya. Smallholder farmers grow most of the crop after which virtually all the produce is exported to Europe. Estimate indicates that up to 50,000 smallholder families are involved in Snap bean production in Kenya (Michalik et al., 2006). Recent data show that almost 100,000 families derive income directly from the export of this crop and another 500,000 derive income indirectly from export of this crop (Lohr et al., 2005). Snap bean is a potential crop that should be promoted in order to uplift living standards of smallholder farmers in rural areas. Snap beans can be harvested 45 days after planting and farmers are paid upon delivery of beans. These beans provide for the daily needs for many small holder families.

However, the production of Snap beans is hindered by many biotic and abiotic factors. For example, most seeds are imported from other countries where they are produced and patented, and hence are not adapted to the local climatic factors Kimani et al., (2004). Michalik et al., (2005), Kasina et al., (2006) and Nderitu et al., (2007) reported that over 60 per cent of yield loss of the marketable fresh pods is caused *F. occidentalis* (Pergande) and *M. sjostedti* (Trybom) flower thrips.

Farmers rely on foliar pesticides for the control of snap bean flower thrips and especially insecticides that includes Thiacloprid, Methiocarb, Deltamethrin, Cypermethrin, Spinosad and Fiprinol Lohr, et al., (2005). Pesticide applications are frequent, sometime between 4-15 times Nderitu et al., (2007); Kasina et al., (2006) in a crop cycle. This high rate of application is worrisome considering the short growing cycle of the crop (a crop may take
12 weeks in the field). Furthermore, harvesting is done daily or every other day. As a result, farmers observe extremely short pre-harvest interval of a few or even one day only.

The introduction of the Maximum Residual Level for export vegetables by the European Union Good Agricultural Practices (EuroGAP) is a potential complication for the Snap bean export because of ensuring compliance by a large number of small holder growers with safe plant protection measures (Anon, 2006b). Snap bean farmers have to ensure that the pods are produced with minimum applications of pesticides, and that pre-harvest intervals are strictly observed. There is a need therefore to diversify flower thrips control strategies in order to minimise pesticides applications in Snap bean farming. Several cultural practices including crop rotation, mixed cropping, strip cropping and flooding have been known to minimise bud flower thrips in other legumes Lohr et al., (2005). Other thrips management strategies include biological (natural or applied) and use of resistant varieties.

The low biodiversity sole cropping may favour pests over the natural enemies and enhance recurrent pest out breaks while mixed cropping improves the number of thrips predators. Nampala et al., (2002) observed that intercropping cowpea with sorghum effectively reduced the population of *Megalurothrips sjostedti* in Kampala, Uganda. When French beans were intercropped with *Tagete erecta* or *Coriandrium sativum* in Mwea-Tebere, Kenya the population of thrips was significantly reduced Kasina et al., (2006). These two studies confirm earlier report by Gitonga et al., (2002) that thrips prefer open area than a shaded one.
A study by Lohr et al., (2005) on Integrated Pest Management found that planting margin crop like grass around Snap bean crop promote biodiversity of edge fauna, including beneficial insects and spiders that suppress thrips multiplication. A cropping system that enhances consistent population of beneficial fauna put ecological pressure on thrips pests. Margin fauna do not necessarily eliminate thrips but they keep them below economical injury level. This study was conducted to evaluate the effectiveness of different pesticides and cropping systems in managing flower thrips in Snap bean crop.

1.1 Justification

Among arthropods pests *F. occidentalis* Pergande and *M. sjostedti* Trybom thrips are major pests of Snap bean and are widely distributed in Kenya. They attack Snap bean at all development stages; young plant, flower bud, open flower and young pod (Lohr et al., (2005); Nderitu et al., (2007) and they are associated with qualitative and quantitative loss of final produce (pod) of Snap bean. Snap bean pods are produced virtually for the export market only and especially in Europe. Most small holders farmers are expected to produce high quality pods for the export market. Production of high quality snap bean pods requires use of pesticides to control thrips throughout the planting. Heavy use of pesticide may exceed the Maximum Residual Level acceptable to European Union Good Agricultural Practices (EuroGap) or other certifying body like, KEPHIS (Kenya Plants Health Plant Inspection Services). Secondly, pesticides have undesirable effect like development of resistance by thrips species; out break of non target secondary pests; which then become major pests elimination of thrips natural enemies; pollution of the environment which may poison the untrained pesticide applicator Michalik et al., (2006). There is therefore need to develop an Integrated Pest Managements system suitable for beneficial insect
multiplication and unsuitable for the pest reproduction. This study seeks to evaluate a cropping system in a farm that maintains a balanced functioning IPM system. The IPM must be affordable, acceptable, safe and sustainable.

1.2 General Objective

To develop affordable, effective and ecological friendly thrips pest management strategies on Snap bean farming.

1.2.1 Specific Objectives

1 To compare the effectiveness of different cropping systems in suppressing flower thrips population on Snap bean crop.

2 To evaluate the efficacy of different pesticides in suppressing flower thrips population on Snap bean crop.

1.3 Hypothesis

1. Population of Snap bean flower thrips differs significantly with cropping systems.

2. The population of Snap bean flower thrips is suppressed differently by different pesticides
1.4 References


CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Snap Beans Classification and Production

Scientifically Snap beans are grouped in the Kingdom, Plantae, Division Spermatophyta, Subdivision Angiospermae, Class Dicotyledon, Subclass Rosidae, Order Fabales, Family Fabaceae or Papilionaceae and Genus Phaseolus and species Phaseolus vulgaris L (Holmes, 1986). There are 20 varieties of Snap bean grown in Kenya (Table 1). The choice depends on yield potential, pest resistance and market demand by consumers. There are various common names given to Snap beans such as String bean, Haricot bean, Green bean and French beans (Anon, 2006a).

<table>
<thead>
<tr>
<th>Fresh market varieties</th>
<th>Processing varieties</th>
<th>Dual purposes varieties</th>
</tr>
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<tbody>
<tr>
<td>Samantha</td>
<td>Julia</td>
<td>Bronco</td>
</tr>
<tr>
<td>Amy</td>
<td>Vernandon</td>
<td>Coby</td>
</tr>
<tr>
<td>Paulista</td>
<td>Gloria</td>
<td>Espadia</td>
</tr>
<tr>
<td>Pekera</td>
<td>Monel</td>
<td>Bakara</td>
</tr>
<tr>
<td>Teresa</td>
<td></td>
<td>Claudia</td>
</tr>
<tr>
<td>Cupvert</td>
<td></td>
<td>Tokal</td>
</tr>
<tr>
<td>Rexas</td>
<td></td>
<td>Supermonel</td>
</tr>
</tbody>
</table>

*Source: (Anon, 2006a).

The most suitable areas for the production of Snap beans fall within lower mid lands and lower high lands ecological zones which includes areas of Nairobi, Kiambu, Muranga, Embu, Meru, Kisii, Uasin Gishu, Kirinyaga, Nyandarua, Keiyo Marakwet, Kakamega, Naivasha, Nakuru, Machakos, Makueni, Taita Taveta, Nyeri, Bungoma, Trans Mara, Vihiga, and Kericho (Anon, 2006a). Snap beans do well in altitude between 1500m and
2000m above sea level and temperature ranging from 18 degrees Celsius to 28 degrees Celsius depending on the variety (Anon, 2006a). Most Snap bean crops are grown using irrigation, because heavy rains adversely affects pollination though moderate rainfall of 900mm-1200mm per annum is suitable for the rain fed crop. Snap beans prefer a wide range of soil type ranging from light sandy loam to clay. They however grow best on friable medium loam soils that are well drained and have a lot of organic matter. The optimum soil for Snap beans ranges from pH 6.5 -7.5.

Snap bean (*Phaseolus vulgaris* L) is one of Kenya’s most important export vegetable crops whose value is steadily rising. The crop is grown mainly for the fresh export market to Europe. However, processing of immature pods including canning and freezing is steadily increasing (Anon 2006a). Estimate indicates that up to 50,000 smallholder families are involved in Snap bean production in Kenya. Recent data shows that almost 100,000 peoples earn an income from Snap bean production and another 500,000 derive income directly or indirectly from export of this crop (Michalik *et al.*, 2005). It is therefore a potential crop which should be promoted in order to uplift living standard of smallholder families in rural areas and especially women and youth.

Snap bean are ranked first among export horticultural vegetable crops in Kenya and contributes about 25% by value of all the horticultural export crops in the country (Anon, 2007). When are compared with dry bean, Snap bean earns fourteen fold more in terms of dry weight basis. Snap bean pods earned the country 9 billion in 2006 (Anon, 2007) which is 45% of all the horticultural export earnings. Local production stands at 26,818 million tons in 2002, 31,319 million tons in 2003, 48,487 millions tons in 2004, 62,189 millions tons in 2005 and 43,821 millions tons in 2006 an upward trend except in 2006 when
production dropped (Table 2). Among the 43,821 millions tons of the pods produced in 2006, 350,000 tons were processed and the rest exported unprocessed (Anon, 2007). Snap bean pods export value has contributed 45% by value and 50% by volume of all the vegetables export crop in the last five years (Anon, 2007).

Table 2: Value of horticultural crops from Kenya in million KSh

<table>
<thead>
<tr>
<th>YEAR</th>
<th>VEGETABLE</th>
<th>CUT FLOWER</th>
<th>SNAP BEAN</th>
</tr>
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<tbody>
<tr>
<td>2002</td>
<td>10,47192.2</td>
<td>14,792.3</td>
<td>5,407.2</td>
</tr>
<tr>
<td>2003</td>
<td>10,591.0</td>
<td>16,495.53</td>
<td>7,271.6</td>
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<td>2004</td>
<td>11,820.5</td>
<td>18,092.0</td>
<td>5,529.9</td>
</tr>
<tr>
<td>2005</td>
<td>13,574.6</td>
<td>22,238.0</td>
<td>7,682.5</td>
</tr>
<tr>
<td>2006</td>
<td>17,823.0</td>
<td>23,569.0</td>
<td>9,143.7</td>
</tr>
</tbody>
</table>


Smallholder growers purely for export in western countries and mostly Europe produce snap beans (*Phaseolus vulgaris* L.) The year round production, in order to maintain continuous, picking of pods for daily sale has encouraged stagger planting of the crop (Anon, 2006a). Other production constraints include insects and diseases, farm inputs, such as fertilizers, marketing of the commodity, transportation, storage facility and intermediaries.

### 2.2 Snap Beans Production Constraints

There are many production constraints of snap beans ranging from biotic and abiotic factors. Biotic factors include insect pests and diseases, while abiotic factors are farm
inputs like fertilizers, marketing of the commodity, transportation, storage facility, and intermediaries.

Snap beans insect pests classified in order of economic importance are as follows:

a) The Bean stem maggot (Ophiomyia spp: Diptera), which infests early in the planting,

b) Western flower thrips (F. occidentalis P) (Thysanoptera; Thripidae),

c) Bean flower thrips (M. sjostedti T) (Thysanoptera; Thripidae),

d) Bean aphids (Aphid fabae) (Aphidae),

e) Red spider mites (Tetranychus spp),

f) African boll worm (Helicorvepa armigera),

g) Legume pod borer (Maruca testuralis) and

h) White fly (Bemisia tabaci) (Anon, 2006 b; Michalik et al., 2005)

Western flower thrips and bean flower thrips are ranked second pest status of snap beans (Michalik, et al., 2005; Nderitu et al., 2007). The two species feed on flower buds, open flowers, pods, and young leaves (Plate 1). The damage caused by the two species involves sucking of plant sap and feeding on parenchyma cells. The symptom of damage by their feeding includes flower malformation and premature abortion, leaves defoliation and distortion and silvering of pods (Plates 2 and 3). Snap bean pod loss of 60 per cent has been reported (Nderitu et al., 2007). Western flower thrips also serve as vectors of Tospoviruses including INSV (Impatient Necrotic Spot Virus) and TSWV (Tomato Spotted Wilt Virus), Groundnut Ring Spot Virus (GRSV), Chrysanthemum Stem Necrosis Virus (CSNV) and
Tomato Chlorotic Spot Virus (TCSV) Whitfield et al., (2005). Tospoviruses are acquired during the larval stage of western flower thrips that feed on diseased plants. The viruses then multiply inside the salivary glands and other tissues of the thrips as it matures. It is not possible for adult thrips to acquire and then transmit any of these viruses (Moritz et al., 2004).

Plate 1: A flower with visible thrips (Michalik et al., 2006)
Plate 2: Fine Snap bean pods

Plate 3: Coiled Snap bean pods Michalik et al., (2006)
2.3 Biology and Ecology of *Megalurothrips sjostedti* Trybom (Bean flower thrips)

2.3.1 Taxonomy, biology and geological distributions
Bean flower thrips are classified in order *Thysanoptera*: family *Thripidae*, genus *Megalurothrips spp*, Species *Megalurothrips sjostedti* Trybom (Plate 4). Bean flower thrips is an indigenous species in Africa and is a wide spread bean pest (Gitonga et al., (2002, Lohr et al.,(2005). It is polyphagus, feeding mainly on legume flowers and is a serious pest of beans and cowpeas in Uganda and Kenya (Nampala et al.,(2002); (Gitonga et al.,(2002); Lohr et al , (2005)and Kasina et al., (2006). The adult thrips is a tiny black insect which is about 1.5-2.5 mm long and has a whitish band across the pronotum. The adult lays eggs under dead plant leaves or plant tissues. The emerging nymph is cream in colour ,but changes into orange after feeding . Pupation occurs under the soil at a depth of 1.5 -2.0 cm deep. The adults are whitish during the emergence but change into black colour after feeding for 48 hours. Both adult and nymph feed in the flower at the base of petals and stigma. They also attack young pods causing punctures which can be observed with a hand lens.
Plate 4: Adult *M. sjostedti* (Michalik et al.; (2006))
Bean flower thrips damage in severe conditions, include flower malformation, distortion and discolouration. Very severe infestation on flower bud causes them not to open but abort prematurely (Lohr et al., 2005).

### 2.3.2 Morphology of *Megalurothrips sjostedti* Trybom (Bean flower thrips).

A mature adult of *M. sjostedti* measures about, 2.0mm long. Their body is shinny black and with a white band on the pronotum. The female lays whitish oval eggs, which are inserted into plant tissues by ovipositor. The egg hatches into a creamy white nymph that changes into orange on feeding. Nymphs are active feeders. Pupation occurs under the soil or dead plant materials. The emerged adult is white in colour but change into black colour on feeding.

### 2.4 Biology and Ecology of *Frankliniella occidentalis* (Pergande) (Western flower thrips)

#### 2.4.1 Taxonomy, Biology and Geographical Distribution

Western flower thrips is classified in order *Thysanoptera*, family *Thripidae* genus *Frankliniella* spp. Species *F. occidentalis* P. This is an exotic south American thrips species which was accidentally introduced to Europe and North America in 1980s and has since spread to the entire world including the rest of Europe by 2003 (Kirk and Terry, 2003). *F. occidentalis* has well adapted to hot climatic condition of East Africa (Gitonga et al.,(2002). This species can be identified by observing a short pair of setae between a long pair of anteromarginal setae on pronotum and a head with ocellar triangle and a pair of long ocellar.
2.6 Morphology of *Frankliniella occidentalis* (Pergande) (Western flower thrips)

The adult female of western flower thrips measures approximately 1.3-1.4mm and male 0.9-1.1mm in length (Plate 5). Both sex are brownish yellow in colour when mature. Female lays its eggs on young plants leaves, flower buds or flowery young pod (Lohr *et al.*, 2005, Gitonga *et al.*, (2002); Kasina *et al.*, (2006). There are two active larval instars that feed on plant tissues. The first larval instar is glassy white in colour, but changes into yellow after feeding. The second larval instar is waxy yellow. Pupation occurs under fallen plant leaves or 1.5 cm under the soil (Plate 5).

![Plate 5: Frankliniella occidentalis at different development stages (Lewis, T. 1997)](image-url)
2.5 Thrips Management Strategies

There are various methods of managing thrips in Snap bean farming, which includes: use of pesticides, use of biological organisms or pathogens, cropping systems or cultural practices and use host resistance.

2.6 Pesticides

Snap bean (*Phaseolus vulgaris* L) is an important cash crop in Kenya. It is grown by small holder farmers with farm sizes ranging from 0.25 – 1.0 ha. These farmers would wish to maximise production and yields. The year round production encourages insect pest infestations. Thrips are major pests of Snap bean and cause over 60% of crop yield loss of marketable pods Nderitu *et al.*, (2007).

Most farmers rely on foliar pesticides to control thrips (Lohr, *et al.*, (2005). *Frankliniella occidentalis* P. has been found to have developed resistance to some of the pesticides like L-Cyhalothrin (Karate1.75) (Kasina *et al.*, (2006). Few pesticides (Methiocarb, Spinosad, Fipronil Kasina *et al.*, (2006); Lohr *et al.*, (2005) have been found to have a good control of both *Frankliniella occidentalis* and *Megalurothrips sjostedti* in legumes. However, spraying should be done during the flower buds development only because thrips hide and feed inside the flowers, where they are sheltered from pesticides penetration.

Foliar pesticide applications should be avoided after the pods are ready for harvesting in order to prevent post-harvest residues on the final yield. Although pesticide applications is the surest management practice for thrips on Snap bean crop, most of the pesticides are expensive to the small-scale farmers and pollute the environments. Their application is regulated by consumers through the development of Maximum Residue Level, code of conduct. Snap beans consumers demand certificate of compliance from producer to ensure
that the produce has undergone inspection, auditing and certification to be in line with international bureau of standards such as Africert, Veritas, SGS and KEPHIS among others. These regulations have put many constraints on small-scale farmers in rural areas; therefore alternative thrips management need to be developed.

2.7 Cropping System
This is a proactive thrips management involving manipulation of the farm agro ecosystem to make it suitable for proliferation of the thrips pest natural enemies and unsuitable to the thrips. It involves maintaining a healthy and biological active soil (increasing below ground biodiversity), creating a suitable habitat for beneficial thrips pests (increasing above ground biodiversity), and without harming the crop or the farm itself. Most farmers neglect the technology because they want to have pest free crop or they have little knowledge of its benefit.

Some of the cropping systems adopted worldwide to suppress thrips in legumes include; crop rotation, intercropping, multiple cropping, flooding, mulching ,margin-cropping and strip cropping . The additional crop on the farm increases intra fauna, margin fauna or nitrogen fixation. Sole-cropping results, to decreased biodiversity that tend to favour crop pest over the natural enemies. Sole cropping encourages pests which were there in the previous planting to emerge after the next planting. Intercropping cow pea with sorghum in Kampala, Uganda significantly reduced the population of cowpea flower thrips \textit{Megalurothrips sjostedti} Trybom in the cowpea crop (Nampala et al., (2002).

Asiwe et al.; (2005) reported that in Nigeria the population of \textit{M. sjostedti} on cowpea flowers was reduced significantly when the cowpea plant spacing was maintained at a range of 1.0 – 1.5 m apart while Kasina et al. ,(2006)observed that when French beans
were inter cropped with coriander (*Coriandrum sativum*) or African marigold (*Tagetes erecta*), the number of thrips were significantly reduced on the French beans crop.

The above three observations confirm earlier study by Gitonga et al., (2002), that thrips prefer open area to shaded one and that is why their number reduced when crops were intercropped or planted very close to each other. The other possible mechanism of close spacing and intercropping is for the inter crop attracting the insect pest (thrips) or margin crop repelling them from the main crop (Snap bean). Crop rotation radically alters the environment of the field usually to the disadvantage of pests of the previous crop. Crop rotation reduces previous crop pest build up; while mulching and flooding suffocate the developing pupa under the soil. Margin cropping and inter cropping are farming systems which need to be evaluated to determine their effectiveness in suppressing Snap beans flower thrips population. Margin crop and inter crop provide a suitable habitat for the thrips natural enemies, provide nitrogen fixation, and reduce light intensity, thus suppress thrips multiplication. The aim of margin cropping and intercropping is to reduce thrips pest below economical injury level. Cropping system method does not seek to eliminate thrips on the crop but rather than maintaining them below economic threshold level.

### 2.8 Biological Control

The use of living organisms include: parasites, predators or pathogens to maintain thrips pest population below economical injury level. Biological control may be natural or applied depending on the nature of organism. Natural biological control includes: Parasitic wasps, predacious bugs, predacious mites, pathogenic fungi and nematodes. The applied natural enemies includes *Orius* spp, ear wings, spiders and *Amblyseuis cucumeris* (Lohr et al.,

Most Snap beans small holders growers have limited knowledge of biological control practices and therefore rarely use it management of thrips. Bio-rational pesticides are also not readily available in the market and especially in developing countries. Several studies have reported that most of the bio-control pesticides are unable to manage thrips population in legumes (Lohr *et al.*, 2005 and Kasina *et al.*, (2006).
2.9 Thrips Resistant Varieties

Snap bean seed varieties that are cultivated in East Africa are produced in temperate region of Europe and America where they have natural enemies. Seeds are imported into tropical countries for pod production only. In the country of origin, seeds are patented to prevent any breeding without authority from parent country (Kimani et al., 2004). However, in Kenya there are three Snap bean breeding stations: K.A.R.I - THIKA, University of Nairobi and MOI University (Kimani et al., 2004) that are making effort to produce Snap bean seeds that are resistant to thrips or rust. Alabi et al., (2004) in Nigeria reported that there are some cowpea cultivars (Moussa Local) TVU 1509, TV x 3236, Sewe and Sanzi banili) which are resistant to cowpea flower thrips M. sjostedti. The resistance was suggested to have been caused by antibiosis operating in these cultivars. Nderitu et al., (2007) recorded low number of thrips population and pod damage in French bean breeding line Pianati. Other study on thrips resistant varieties on legumes is still going on in KARI-THIKA and University of Nairobi field station. It is therefore necessary to develop and multiply resistant varieties of Snap beans for local use by smallholder farmers. Use of host resistant varieties should be encouraged for use by smallholder growers because they are avoidable, cheap and environment friendly.

2.10 Pros and Cons of Cropping System and Pesticides

Flower thrips are major pest of Snap beans that cause over 60% of yield losses of marketable pod (Nderitu et al., 2007). They are widely distributed in all Snap beans growing area in Kenya. They attack Snap beans crop at all development stages: on young leaves, flowers and pods. Thrips affect commercial plant production in various ways, directly by reducing yield and market quality either through feeding damage or by the transmission of virus disease, but also indirectly when the mere presence of thrips on a pod
is used as a reason for denying it entry to a profitable market. Snap bean pods are produced virtually for export market in Europe. Snap bean pods are produced by smallholder farmers in farm size ranging from 0.25 - 1.0 ha. To maximize crop production and yield per year, farmers’ plant Snap bean seed continuously through out the year. The year round productions, encourages proliferation of insect pests and especially thrips. For effective control of these insects, farmers require heavy use of pesticides throughout the year (Anon, 2006b). Excessive use of pesticides against thrips may bypass Maximum Residual Level set by bean pod importing countries (Lohr et al, 2005).

Pesticides are also costly and harmful to both human and non-targeted organisms. It is therefore important to develop ecological system suitable for the multiplication of natural enemies and unsuitable for thrips pest reproduction. This requires advance planning before any pod production is started in order to ensure that use of pesticides occur when thrips population has reached economical threshold level. A good farming system should seek to manage resources in order to maintain a balanced functioning soil.

The system must be affordable, acceptable, safe and sustainable least input sustainable agriculture system can only be achieved through using bio-intensive integrated pest management as a solution to thrips control in Snap bean farming.

Bio-intensive IPM incorporates ecological and economical factors into agricultural system design and decision-making and addresses public concern about environmental quality and food safety.
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CHAPTER 3

3.0 GENERAL MATERIALS AND METHODS

3.1 Experimental site

The experiments were carried out, in Mwea-Tebere, Central Kenya in a farm located about 100km North of Nairobi city, latitude 0.5 degrees South and longitude 37 degrees East. The land lies 1200m above sea level. The soil is a mixture of red soil and alluvial cotton soil. The experimental area receives two rainy seasons in March and April (long rains) and September to December (short rains). Temperature ranges from 15 degrees Celsius to 28 degrees Celsius.

3.2 Cultivation of Experimental Snap bean crop

Snap bean seeds of variety Samantha were used in the experiments and Katumani maize for margin and inter-crop seeds were bought from certified seed dealers. Samantha variety was selected because it is the most preferred by farmers in that area and most preferred by consumers while maize is least affected by thrips. Before planting, the seeds were dressed with a pesticide (Marshals 350) Imidacloprid to prevent early pest (Bean fly maggot) infestation of snap beans seedlings. In the cropping system experiment, two rows of maize were planted at the edges of the border-crop and inter-crop treatments one week earlier to provide enough leaves for trapping thrips as they emerged from the soil. Two rows of maize were added in the inter-crop plots at 200cm interval leaving a space of four rows of snap beans. Maize spacing was maintained at 15cm x 30cm, while the spacing for snap beans was 60 cm between the rows and 10 cm within the rows. Immediately after snap beans emerges, they were sprayed with Dimethoate (Danadim 40 e c) to control bean fly maggot (Ophiomyia spp), which is very injurious to the crop at this stage of development.
(Nderitu et al., (2007); Gitonga et al.; (2002). These experiments were carried in two plantings having three weeks intervals in between each planting.

3.3 Methodology of experiment

The experiments were carried out in 32 plots per planting each measuring 3mx4m with treatments laid out in Completely Randomised Design and replicated four times because the farm was very homogeneous and flat. Buffer path of 2m was left all round the blocks and plots. Before planting, well-decomposed manure was applied along the rows at the rate of 4 tones per acre and during planting. In addition, Calcium Ammonium Nitrate (C.A.N) fertilizer was applied at the rate of 120kg/ acre during planting as per the recommendation of soil test performed by National Agricultural Research Laboratories in January 2006 (Anon, 2006c). After snap beans seedling emerged, 2-3 leaves stage they were top dressed at the rate of C.A.N 60kg/acre. Commercial foliar feeds Bayfolan, NPK, macro and micronutrient were applied at rate of 500ml/acre during the growing period. The field was kept free of weed by hand weeding at two, four and six weeks after the snap beans crop emerged. Furrow irrigation was done at an interval of three days from the time of planting throughout the crop development, but was stopped when it rained. Margin-crop maize and inter crop maize were planted on 31st January 2006 while snap bean seeds were planted on 8th February 2006 for the first planting. The second planting margin–crop maize and inter-crop were planted on 21st February 2006 and the snap beans crop on 30th February 2006.
3.4 Experimental sampling
Data collection was done twice weekly starting from the fourth week after germination to the time flowers withered. Ten plants were randomly selected from the inner six rows and a flower and a pod picked from each plant. Flowers were kept in 60 per cent alcohol to preserve thrips for later identification, classification and counting. Each flower was emptied into a Petri dish with square grid engraved at the bottom (to facilitate thrips counting) macerated and washed to make sure that no thrips was lost with the debris. Thrips were counted under dissecting microscope using a tally counter, and were classified into *F. occidentalis, M. sjostedti* adults and larvae. Pods were harvested by picking immature pods that were ready for market and graded into marketable and unmarketable grades. Harvesting was done twice a week starting from 50 days after Snap beans emerged for four weeks. From ninety pods sampled from each plot the number of pods showing thrips damage were recorded and categorised into different percentage levels 1= 0-24% damage or slight damage, 2 =25-49% damage or moderate damage, 3 =50-74% damage or high damage and 4= 75-100% damage or severe damage.

3.5 Data Analysis
Data were entered in Ms Excel and analysed with Genstat 9th edition (2006). Where necessary, the number of thrips were square root transformed and the pod damages arcsine transformed to change percentage scale to interval scale and fit assumptions of analysis of variance (ANOVA). Where there was no significant difference in repeated experiments pooled data analysis was carried out. For the treatment that showed significant F-statistic means were separated by standard error of difference of means.
3.6 REFERENCES


CHAPTER 4

4.0 EVALUATION OF CROPPING SYSTEMS AS A STRATEGY FOR MANAGING SNAP BEANS FLOWER THRIPS IN MWEA -TEBERE, CENTRAL KENYA

4.0 Abstract

A field experiment was conducted in Mwea-Tebere, Central Kenya, with the objectives of comparing the effectiveness of cropping systems in suppressing flower thrips; Frankliniella occidentalis Pergande and Megalurothrips sjostedti Trybom on Snap beans (Phaseolus vulgaris L) variety Samantha. The treatments were Snap beans grown with maize (Zea mays L) as margin crop, Snap beans grown with Z. mays as intercrop, untreated Snap beans and sprayed with a pesticide, Thiacloprid (Control). The treatments were laid out in a Completely Randomised Design with four replicates. Flowers and pods were collected from ten randomly selected plants per plot for identifying and counting of thrips. The results indicates that there was significant difference ($P<0.5$) between the four treatments. The lowest number of adult thrips ($M. \text{sjostedti}$ and $F. \text{occidentalis}$) and their larvae was recorded in plots treated with $Z. \text{mays}$ as intercrop, while the highest was the in Snap beans sole plots (untreated) in both plantings. In addition, Snap bean plots treated with $Z. \text{mays}$ as a margin crop had moderate number of thrips. The Thiacloprid treated plots had the lowest number of $M. \text{sjostedti}$, but the $F. \text{occidentalis}$ were marginally affected by this pesticide in the two plantings. In general, the population of $F. \text{occidentalis}$ was higher than that of $M. \text{sjostedti}$ in both plantings. Snap beans plots treated with $Z. \text{mays}$ as intercrop showed the highest percentage of marketable pods whereas the untreated (Snap
beans sole) had the highest number of damaged pods and unmarketable. Thrips natural enemies were high in the crop treated with Z. mays, margin crop and sole-crop but least in Thiacloprid treated plots.

4.2 Introduction
In the group of arthropod pests of Snap beans (Phaseolus vulgaris L.), Western flower thrips (Frankliniella occidentalis Pergande) and Bean flower thrips (Megalurothrips sjostedti Trybom) (Thysanoptera: Thripidae) are ranked as major pests. They have been known to cause over 60 percent loss of marketable pods Michalik et al., (2006); Kasina et al.,(2006); Nderitu et al., (2007). Their feeding on the flowering parts causes abscission of flower buds, open flower peduncles and causes curling of pods, leading to loss of quality of Snap beans pods Nderitu et al., (2007).

Snap beans farmers have relied on chemical pesticides and especially insecticides such as Methiocarb; Thiacloprid; Deltamethrin; Spinosad; Chloropyriphos and Fipronil ,Lohr et al., (2005). The frequency of pesticides application in a crop cycle ranges from four to 15 times. This high pesticides application frequency is particularly worrisome considering the short growing cycle of the snap bean crop (a crop may take 12 weeks in the field). Furthermore, pods harvesting is done daily or every other day. As a result, farmers observe extremely short pre-harvest interval of a few or even one day only. The introduction of Maximum Residual Level for export vegetables by European Union Good Agricultural Practices (EuroGAP) is a potential complication for export industries, because of the difficulties of ensuring compliance by a large number of smallholder growers with safe plant protection measures Anon, (2006a). In addition, most pesticides used for the control
of thrips are expensive to the smallholder grower. There is need, therefore to diversify the control options for flower thrips on Snap beans and minimize pesticides usage.

Several cultural practices have been used worldwide to manage legume flower thrips in cowpea as indicated by Nampala et al., (2002) in Nigeria. Kasina et al., (2006) had observed that intercropping French bean with African marigold (Tagetes erecta) and Coriander (Corandrum sativum), significantly reduced the population of flower thrips on French bean crop. In both intercropping and margin, cropping the farmer does not rely much on the yield of the extra crop, but on their benefit in reducing the pests below economic thresholds. Nevertheless, the farmer benefit from the crop used as an intercrop or margin crop for extra income. The mechanism of margin cropping in pest management is enhancement of the diversity of beneficial insects and spiders in the edges of the main crop, while that of the intercrop is to attract or repel pests from the crop, and manipulation of the environment around the main crop such that the populations of natural enemies of the pest build up (Kasina et al., 2006). This study was aimed at identifying a cropping system that is the most suitable in suppressing the population of flower thrips on Snap bean crops and minimizes the use of pesticides.

4.3 Materials and methods
Snap beans seeds of variety Samantha were dressed with pesticide Imidacloprid to prevent early pest infestation. Four cropping systems namely maize (Zea mays) grown with Snap beans (Phaseolus vulgaris) as margin crop, maize grown with Snap beans as intercrop, Snap beans sole (untreated) Snap beans sprayed with Thiacloprid were evaluated for their efficacy in the suppression of bean flower thrips field population. Treatments were laid out...
in a Complete Randomized Design in plot size of 3mx4m replicated four times. Snap beans plots grown with maize as inter crop was planted two rows of bean one row of inter crop, at intra row spacing of 10cm and inter-row spacing of 60cm, while Snap beans plots grown with maize as margin crop were planted 60 cm all round the main crop. The rows of maize were planted at the edges of the margin crop and inter-crop treatments one week earlier to provide enough leaves for trapping insects thrips as they emerged from the soil. The snap beans sole plots and the insecticides treated plots were planted together with the other two inter crops and margin crops. Insecticide (Thiacloprid) treatment was applied at the rate of 480g/l A.I./Ha (20ml/20L) of water and twice per week in both plantings.

Sampling of thrips on Snap beans flowers was done by randomly selecting ten plants from inner six rows and a flower and a pod were picked from each plant. Flowers were kept in 60 percent alcohol to preserve thrips for latter identification, classification, and counting. Each flower was placed in a Petri dish macerated and washed to make sure that no thrips was lost with the debris. Thrips were counted under dissecting microscope using a tally counter, and classified into *F. occidentalis* and *M. sjostedti* adults and larvae. Pods were harvested by picking immature ones that were ready for market and graded into marketable and unmarketable grades. Harvesting was done twice a week starting from 50 days after Snap beans emergence for four weeks. From ninety pods which were sampled from each plot, the number of pod showing thrips damage was recorded and categorized in different percentage levels where 1= 0-24% damage or slight damage, 2 =25-49% damage or moderate damage, 3= 50-74% or high damage and 4 =75-100% damage or severe damage.
Data analysis were done using Genstat 9th edition (2006). Thrips data was square root transformed and pod damage arcsine transformed to percentage scale to interval scale and fit assumption of analysis of variance (ANOVA). Where there was no significance difference in repeated experiments pooled data was carried out. For the treatments that showed significance $F$-statistic, mean were separated by standard error of difference of means.

4.4 Results
The results indicate that there was significant difference ($P<0.5$) between the four treatments: (*P. vulgaris* grown with *Zea mays* as intercrop, *P. vulgaris* grown with *Z. mays* as margin crop, *P. vulgaris* grown as sole crop, and *P. vulgaris* crop sprayed with a Pesticide Thiacloprid (Table 3). The lowest number of adult thrips (*M. sjostedti* and *F. occidentals*), and their larvae was recorded in plots treated with *Z. mays* as inter- crop while the highest was in *P. vulgaris* sole plots or untreated in both plantings(Table 4; Figure 1 and 2). In addition, *P. vulgaris* plots treated with *Z. mays* as margin crop had moderate number of thrips (Figures 1 and 2). Thiacloprid treated plots had the lowest number of *M. sjostedti*, but the number of *F. occidentals* was marginally affected by this pesticide in the two plantings (Table 4).
Table 3: Mean number of adult thrips (*F. occidentalis* and *M. sjostedti*), their larvae, and natural enemies in both plantings 1 and 2

<table>
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<th><em>F. occidentalis</em></th>
<th><em>M. sjostedti</em></th>
<th>Larvae</th>
<th>Natural Enemies</th>
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</table>

Figure1: Mean number of adult *F. occidentalis* and *M. sjostedti* thrips and their larvae and natural enemies in four cropping systems in planting 1

Key: BC= (Margin crop), CT =Thiacloprid , IC= (*Zea mays* (inter-crop) and MC= (*P., vulgaris* sole crop) NB A season represent treatments in planting 1
Figure 2: Mean number of adult *F. occidentalis* and *M. sjostedti* adults and their larvae and natural enemies in four cropping systems in planting 2

![Bar chart showing thrips counts across different cropping systems](chart.png)

**Key:** BC = (Margin crop), CT = Thiacloprid, IC = (*Zea mays* inter-crop) and MC = (*P. vulgaris* sole crop) NB A season represents a planting

In general, the population of *F. occidentalis* was higher than that of *M. sjostedti* in both planting (Table3)
Figure 3: Mean number of adult *F. occidentalis* and *M. sjostedti* thrips their larvae and natural enemies on Snap bean flowers in plantings 1 and 2

**Key**
- Treatments BC= Snap bean margin crop with *Zea mays*, CT= Thiacloprid, IC= *Zea mays* Intercropped with Snap bean, MC= Snap bean sole crop. NB A season represent a planting.
Table 4: Mean number of adult *M. sjostedti*, and *F. occidentalis* thrips their larvae and natural enemies on *P. vulgaris* in four cropping systems plantings 1 and 2

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Planting 1</th>
<th>Planting 2</th>
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<tr>
<td></td>
<td><em>F.</em> occidentalis sjostedti</td>
<td><em>M.</em> Larvae</td>
</tr>
<tr>
<td></td>
<td><em>F.</em> occidentalis sjostedti</td>
<td><em>M.</em> Larvae</td>
</tr>
<tr>
<td>BC</td>
<td>39.0</td>
<td>12.8</td>
</tr>
<tr>
<td>CT</td>
<td>66.8</td>
<td>2.2</td>
</tr>
<tr>
<td>IC</td>
<td>24.8</td>
<td>8.2</td>
</tr>
<tr>
<td>MC</td>
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<td>16.0</td>
</tr>
<tr>
<td>LSD5%</td>
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<td>12.5</td>
</tr>
<tr>
<td>F</td>
<td>7.21</td>
<td>2.16</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.05</td>
<td>0.146</td>
</tr>
</tbody>
</table>

*Key: Treatments BC=Zea mays as margin crop, CT=Thiacloprid, IC= Zea mays as Intercrop, MC= Phaseolus vulgaris sole crop.

Thrips natural enemies were high margin crop, inter-crop and sole crop treated plots but least in the Thiacloprid treated plots. (Table 4)

They was no significance difference (*P*>0.05) in number of natural enemies during the two snap beans planting.
Figure 4: Mean number of adult *F. occidentalis* (WFT) and *M. sjostedti* (BFT) thrips in planting 1 and 2 of Snap bean crop in Mwea-Tebere

![Graph showing the mean number of thrips over time](image)

The population of *F. occidentalis* was generally higher than that of *M. sjostedti* the two planting period of snap bean crop (Figure 4)

Snap beans crop intercropped with *Zea mays* showed the highest percentage of marketable pods whereas Snap beans sole crop had the highest number of severely damaged pods, which are least marketable (Figures 4 and 5).
Figure 5: Mean percentages of Snap beans pods damage categories in different cropping system treatments in planting I

Key: Treatments are BC=Zea mays as margin crop, CT=Thiacloprid, IC=Zea mays as intercrop, MC = Phaseolus vulgaris as sole crop.
Figure 6: Mean percentages of Snap beans pods damage categories in different treatments in planting 2

Key: BC=Zea mays Margin crop, CT=Thiacloprid, IC=Zea mays Intercrop, MC=P vulgaris (Snap beans sole) NB A season represents a planting
4.5 Discussion

Snap beans plots treated with *Zea mays* as intercrop had the lower number of thrips than the untreated (Snap beans sole) plots in plantings 1 and 2; however, when Snap beans was grown with *Zea mays* as a margin crop the number of thrips were moderate. Thiacloprid treated plots had the lowest number of *M. sjostedti*, but the number of *F. occidentalis* was slightly affected by this pesticide. The Snap beans plots treated with *Zea mays* as intercrop had the highest percentage of marketable pods whereas the untreated plots (Snap beans sole) had the highest number of severely damaged pods. The thrips natural enemies were highest in those plots treated with, *Zea mays* as intercrop, margin crop, and sole crop but least in the Thiacloprid treated plots. *Zea mays* can therefore be incorporated in an integrated pest management of flower thrips in order to lower the costs of production and minimize pesticide application. Previous studies have shown the population of *M. sjostedti* was reduced when cowpea were intercropped with sorghum in Kampala Uganda (Nampala et al., 2002). In Kenya, Kasina et al., (2006) indicated that when French beans were intercropped with *Coriandrium sativum* and *Tagete erecta* the population of thrips is relatively reduced. *Z. mays* has also been reported to suppress the population of *M. sjostedti* when intercropped with cowpea and beans (Kyamanywa et al., 1998; Kyamanywa and Tukalinwa 1998; Emeasor and Esueh, 1997). Another study (Lohr et al.;(2005) had indicated that *F. occidentalis* population are suppressed by several other crops like sweet corn and sorghum and thus could be used for thrips managements. Gitonga et al., (2002) had observed that *F occidentalis* and *M sjostedti* preferred open areas than shaded one, hence are less in the intercropped Snap beans crop. The combination of inter crop and margin crop could be used by those Snap beans farmers who want to produce thrips free produce without necessarily applying pesticides.
4.6 References


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Temperature –dependent development of Megalurothrips sjostedti T and Franklioniella occidentalis P (Thysanoptera :Thripidae) African Entomology, 10:325-331


CHAPTER 5

5.0 EVALUATION OF PESTICIDES AS A STRATEGY FOR MANAGING FLOWER THRIPS ON SNAP BEANS IN MWEA -TEBERE, CENTRAL KENYA

5.1 Abstract

A field experiment was carried out in Mwea–Tebere, Central Kenya, with the objective of evaluating the effectiveness of pesticides, Thiacloprid, Azadirachtin 0.15 % A.I, Azadirachtin 0.06% A.I and Chloropyriphos in suppressing field populations of *F. occidentalis* Pergande and *Megalurothrips sjostedti* Trybom flower thrips on Snap beans (*Phaseolus vulgaris* L). The treatments were laid out in Complete Randomized Design with 4 replicates. Flowers and pods were collected from ten randomly selected plants per plot for identifying and the counting of thrips. Each flower was macerated and washed with 60% alcohol to ensure that no thrips were lost with debris.

The results indicate that there was significant different ($P < 0.05$) between the four treatments. The lowest number of adult *M. sjostedti* and *F. Occidentalis* thrips and their larvae was recorded in plots treated with Azadirachtin 0.15% A.I and Chloropyriphos. Snap bean plots treated with Thiacyloprid and Azadirachtin 0.06 % A.I recorded the higher number of *F. occidentalis* and *M. sjostedti* adult thrips in both plantings. Snap bean plots treated with Chloropyriphos showed higher percentage of marketable pods than those treated with Azadirachtin 0.06 % A.I and Azadirachtin 0.15% A.I in both plantings.

In general, the population of thrips decreased with the application of pesticide. These results shows that applying Azadirachtin 0.15 % A.I and Chloropyriphos in a Snap bean crop minimize the number of flower thrips and increase the yield of marketable pods.
5.1 Introduction

Snap bean (*Phaseolus vulgaris* L.) is the second major export crop in Kenya and account for up to 55% by volume of all vegetable export crops Anon, (2006a). There is high demand for Snap beans pods in Europe and especially during winter.

Snap beans are produced by small holder growers in farm size ranging between 0.25-1.0ha Nderitu *et al.*, (2007). The production is continuous throughout the year in order to maintain the crop demand in the export market and also get high income. The year round production is hindered by insect pests and diseases which are major constraints Michalik *et al.*, (2006)

In the group of arthropod pests, thrips (*F. occidentalis* and *M. sjostedti* (*Thysanoptera: Thripidae*) are major pests of Snap bean crop. They feed on all development stages, young leaves, flower buds and young pods. When feeding on young plant leaves they suck cell sap resulting to stagnant growth, while on young flower buds they cause abortion of premature flowers and in pods they cause coiling leading to quality loss.

Snap beans farmers depend on foliar pesticides, cultural method, biological control and host plant resistance varieties. Among the pesticides mostly applied includes Fipronil, Spinosad, Methiocarb, Thiacloprid and Deltamethrin. Nevertheless, due to selective nature of thrips (most of them live under the petals where pesticides are difficult to penetrate) Snap bean farmers spray many times in a crop cycle in order to control them.

Secondly, pesticides can only be sprayed during the flowering period for effective thrips management. Nabirye *et al.*, (2003) had observed that a pest management that combines early planting, close spacing and three insecticides application once at budding, flowering
and podding stages reduced the population of cowpea buds thrips *M. sjostedti* Trybom in Eastern Uganda.

Use of foliar pesticides has been known to be the surest method of managing flower thrips on a Snap bean crop Lohr, *et al*., (2005). A few chemical pesticides and plant extracts have shown some good control of thrips. Kasina *et al*., (2006), and Lohr *et al*., (2005) indicated that Methiocarb (Mesurol), Spinosad and Fipronil significantly reduced the population of thrips in French bean crop. Plant derivatives have good control of cowpea flower thrips in Nigeria and Uganda respectively by a study by Thoeming *et al*., (2006) who found that when bean seeds were dressed before planting with Neem extracts (Azadirachtin and 3 – Trigloazdirachtol) the population of western flower thrips *Frankliniella occidentalis* (*Thysanoptera: Thripidae*) was effectively reduced in flowers. Oparaeke *et al*., (2006) performed two experiments in Nigeria and observed that Nigerian spices *Piper guineese*, *Afromomum melagueta*, *Xylopia aethiopica* and *Zinger officinarum* at 10% concentration sprayed once weekly for 4 weeks on cowpea flowers reduced the population of *M. sjostedti* on a cowpea crop and offered significant protection to cowpea flowers compared to the untreated crop. Another study by Oparaeke, (2006) had deduced that crude extracts of *Gmelina arborea* reduced thrips infestation on Cowpea crop significantly. Addition study by Asawalam (2006) in Nigeria had indicated that a combination of crude extracts of *Azadirachtin indica* and *Ocimum grassimum* spray significantly reduced bud flower thrips *M. sjostedti* on cowpea plants. This study was conducted to evaluate the effectiveness of four pesticides in managing Snap beans flower thrips on Snap beans crop in Mwea- Tebere Central Kenya.
5.2 Materials and methods

The study was carried out in Mwea- Tebere ,Central Kenya 2006 Snap bean seeds variety, Samantha were bought from certified seed dealer. All seeds were treated with Imidacloprid before planting to prevent early soil pest like Bean Stem Maggot (Ophyiomyia spp). The land was fine ploughed using a disk plough tractor, then divided into 32 plots of 3m x 4m and a buffer of 2M was left all round. Planting furrows were made manually for seed sowing. At planting Calcium Ammonium Nitrate was applied at the rate of 500kg/hac but mixed well with soil before planting. Farmyard manure was applied in each furrow at the rate of 2 tons per ha. Calcium ammonium nitrate (C.A.N) was applied at the same rate as at planting during the second and fourth week after crop emergence.

Treatment for both plantings were 4 plots sprayed with Azadirachtin 0.15% A.I, 4 plots treated with Azadirachtin 0.06 % A.I, 4 plots treated with Chloropyriphos and 4 plots with Thiacloprid . Each pesticide was mixed separately with clean water before planting in a level operated solo knapsack sprayer. Pesticide application was at the rate of Thiacloprid 20ml/20litre of water, Chloropyriphos 20ml/20 litres of water, Azadirachtin 0.06% A.I 40ml/20 litres of water and Azadirachtin 0.15% A.I 20 ml/ 20 Litres of water. All the treatments were laid out in a Complete Randomized Design in all the 32 plots.

Pesticides spraying started after fifty percent of plant flowering and continued for one month or twice per week. Ten plants from the inner six rows were selected randomly and a flower and a pod picked until the flower withered. The flowers were kept in universal bottle containing 60 percent alcohol to preserve thrips for later identification, classification and counting. Pods were puts in polythene bags for the assessment of thrips pod damage in the
laboratory. Flowers were put in Petri dishes engraved with square grid for ease thrips counting. Each flower was macerated separately and washed with 60% alcohol to ensure that no thrips were thrown with the debris. Counting of thrips was done under a dissecting microscope and was separated into *F. occidentalis* and *M. Sjostedti* adults and larvae. Pod from each plots were physically assessed for thrips damage and percentage scale score was used 1=0% -24% no damage or slight damage, 2 = 25-49% damage or moderate damage, 4=50-74 % damage or high damage, 5=(75-100% damage or severe damage. The pod damage score was arcsine transformed to fit in analysis of variance (ANOVA) test between the four pesticides. Mean were separated by S.E.D when the treatments effect showed significant F-test.

5.3 Results
The results indicate that there was significant difference (*P*<0.05) in all pesticide treatments (Table6). Snap bean plots treated with Azadirachtin 0.15 % A.I had the lowest number of adult *F. Occidentalis* Pergande and *M. sjostedti* Trybom thrips and their larvae in plantings 1 and 2 (Table 6). Snap bean plots treated with Azadirachtin 0.06% A.I and Thiacloprid had higher number of thrips in the planting 1and 2 , whereas those sprayed with Chlorophyriphos had moderate number of thrips. Thiacloprid pesticide had minimal effect on *F. occidentalis* in both planting (Figures7and 8). There was no significant difference between the numbers of natural enemies in all the Snap bean plots treated with the four pesticides (Table5). Nevertheless, plots treated with Azadirachtin and Chlorophyriphos had slightly more natural enemies than Thiacloprid treated plots.
Table 5: Mean number of adult *F. occidentalis* and *M. sjostedti* thrips and their larvae and natural enemies in planting 1 and 2

<table>
<thead>
<tr>
<th>Planting</th>
<th><em>F. occidentalis</em></th>
<th><em>M. sjostedti</em></th>
<th>Larvae</th>
<th>Natural Enemies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting 1</td>
<td>79.0</td>
<td>8.25</td>
<td>47.5</td>
<td>1.8</td>
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<tr>
<td>Planting 2</td>
<td>89.5</td>
<td>12.81</td>
<td>73.1</td>
<td>1.2</td>
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<tr>
<td>LSD (5%)</td>
<td>11.1</td>
<td>3.44</td>
<td>8.2</td>
<td>1.02</td>
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<td>&gt;0.05</td>
<td>&lt;0.05</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

The four pesticides had significant difference (*P*<0.05) in the number of adult thrips and their larvae in both plantings. Snap bean plots treated with Azadirachtin 0.15% A.I and Chloropyriphos had lower number of *F. occidentalis* and *M. sjostedti* in planting 1. Thiacloprid and Azadirachtin 0.06% A.I treated plots had higher number of both species of thrips in planting 1. Snap bean plots treated with Thiacloprid had the lowest number of *M. sjostedti* but had no effect on *F. occidentalis* in plantings 1 and 2 (Figures 7 and 8). Generally, all the plants derived pesticides reduced the number of flower thrips and their larvae in Snap beans crop.
Figure 7: Mean number of adult *F. occidentalis* and *M. sjostedti* thrips their larvae and natural enemies on Snap bean crop treated with pesticides) in Mwea-Tebere

The Snap bean plots treated with Azadirachtin 0.15% w/w and Chloropyriphos had the lowest number of *M. sjostedti* and *F. occidentalis* adults thrips in plantings 1 and 2, whereas, Azadirachtin 0.06% A.I had the highest number thrips. There was no significant difference (*P* > 0.05) in the number of natural enemies (*Orius* spp) among all the four pesticide treatments in both plantings (Table 6).
Table 6: Mean number of adult *F. occidentalis* and *M. sjostedti* thrips and their larvae and natural enemies (*Orius* spp) in Snap bean crops in planting 1 and 2

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Planting 1</th>
<th></th>
<th></th>
<th>Planting 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FO</td>
<td>MS</td>
<td>Larvae</td>
<td>Natural</td>
<td>FO</td>
<td>MS</td>
</tr>
<tr>
<td>Pesticides</td>
<td></td>
<td></td>
<td></td>
<td>Enemies</td>
<td></td>
<td></td>
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<tr>
<td>AT</td>
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<td>15.2</td>
<td>46.2</td>
<td>2.25</td>
<td>72.8</td>
<td>23.5</td>
</tr>
<tr>
<td>CT</td>
<td>92.2</td>
<td>2.8</td>
<td>51.2</td>
<td>1.5</td>
<td>109.2</td>
<td>4.8</td>
</tr>
<tr>
<td>ET</td>
<td>102</td>
<td>12.2</td>
<td>58.2</td>
<td>2.25</td>
<td>92.5</td>
<td>16</td>
</tr>
<tr>
<td>PT</td>
<td>72</td>
<td>2.8</td>
<td>34.2</td>
<td>1.25</td>
<td>83.5</td>
<td>7</td>
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<td>LSD (5%)</td>
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<tr>
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<td>8.92</td>
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<td>0.44</td>
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<td>&lt;0.05</td>
</tr>
</tbody>
</table>

*Key:* AT= Azadirachtin 0.15% A.I, CT=Thiacloprid, ET= Azadirachtin 0.06% A.I, PT=Chloropyriphos, FO = *F. occidentalis*, MS= *M. sjostedti*

Snap bean plots treated with Azadirachtin 0.15% A.I and Chloropyriphos had the lowest number of bean flower thrips and western flower thrips in planting 2 whereas those treated with Thiacloprid and Azadirachtin 0.06% A.I had relatively higher numbers of both species (Figure 8).
Figure 8: Mean number of adult *F. occidentalis* and *M. sjostedti* thrips larvae and natural enemies (Orius spp) in planting II of Snap bean treated with pesticides in Mwea-Tebere

- **F. occidentalis**
- **M. sjostedti**
- **Thrips Larvae**
- **Thrips natural enemies**

**Key:**
- AT = Azadirachtin 0.15% A.I.
- CT = Thiacloprid
- ET = Azadirachtin 0.06% A.I.
- PT = Chloropyriphos
Figure 9: Mean number of adult *F. occidentalis* and *M. sjostedti* thrips larvae and natural enemies (*Orius* spp) on Snap bean crop treated with pesticides in planting 1 and 2

![Bar chart showing thrips counts per ten flowers for different treatments]

**Key:**
- AT = Azadirachtin 0.15% A.I.
- CT = Thiacloprid
- ET = Azadirachtin 0.06% A.I.
- PT = Chloropyriphos

There was an increase in number of *F. occidentalis* and *M. sjostedti* flower thrips in both plantings, although *F. occidentalis* seem to be more during the first planting than the second planting as indicated by (Figures 9 and 10) below.
Figure 10: Mean number of adult *F. occidentalis* (WFT) and *M. sjostedti* (BFT) thrips during planting I and II of Snap beans crop treated with four pesticides

The number of thrips decreased with the application of pesticides during the fourth week of spraying. These study shows that there was significant difference in the number of thrips (*P*<0.05) between all the four pesticides and the Snap beans pod damage during the first planting but there was no significant difference in pods damage during the second planting of the Snap bean crop (Figures 11 and 12).
Figure 11: Mean percentages of Snap bean pods damage categories in different pesticides treatments on Snap bean crop in planting 1 in Mwea-Tebere

![Pesticides Treatment Planting I diagram](image)

During planting 2 which was rain fed, the percentage of marketable Snap bean pods increased to over 70% (Figure.12).
The Snap beans plots treated with the four pesticides had no severely damaged pods during planting 2 and the number of marketable pods was high above 70% in all the treatment. This could have been caused by adequate rainwater that washed away most of the thrips or due to the recovery of the affected Snap bean plants. (Figure 12).
5.4 Discussion
Snap bean plots treated with Azadirachtin 0.06% A.I, had more thrips than snap bean plots treated with Azadirachtin 0.15% A.I whereas, the chloropyriphos treated plots had moderate number of thrips in both plantings. The Thiacloprid pesticide had minimal effect on *F. occidentalis* however, very effective on *M. sjostedti*. Azadirachtin 0.15% A.I was more effective compared with Azadirachtin 0.06% A.I in controlling *F. occidentalis* and *M. sjostedti* adults and their larvae. Thrips natural enemies did not vary across the four pesticides treatments; however, snap bean plots treated with Azadirachtin and chloropyriphos had more natural enemies than the Thiacloprids treated plots. The two pesticides Azadirachtin and Thiacloprids can be incorporated in an IPM system on thrips management.
5.5 References

Crop development Department 283 Ministry of Agriculture Kenya


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6.0 General discussion

The population of adult *F. occidentalis* and *M. sjostedti* adults were high during the second planting than the first planting. Among the cropping system treatments evaluated, the snap beans crops grown with *Z. mays* as intercrop had the lowest number of *F. occidentalis* and *M. sjostedti* adults thrips in both planting 1 and 2. Snap beans crops grown with *Zea mays* as a margin crop had moderate number of adult thrips, whereas those crops grown as sole or untreated had the highest number of adult flower thrips.

Thiacloprid treated plots had the lowest number of *M. sjostedti* but the number of *F. occidentalis* was marginally affected by this pesticide in the two plantings. In general, the population of *F. occidentalis* was high during the two plantings. Snap beans plots treated with *Z. mays* as intercrop had the highest percentage of marketable Snap bean pods, whereas the untreated plots had the highest percentage of severely damaged pods that were least marketable. Natural enemies (*Orius* spp.) were high in crops treated with *Z. mays* as intercrop, margin crop and sole crop but least in the Thiacloprid treated plots.

Earlier report by Nabirye *et al.* (2003); Nampala *et al.*, (2002), Kasina *et al.*, (2006) had indicated that intercropping legumes with other crops reduces population of thrips significantly. The *Z. mays* intercrop or margin-crop should be used by Snap beans growers to earn extra money or as food.
Pesticides treatments showed significant difference $P<0.05$ in thrips infestation during the two plantings. Azadirachtin 0.15% A.I and Chloropyriphos had the lowest number of *M. sjostedti* and *F. occidentalis* adults thrips in plantings 1 and 2, while Azadirachtin 0.06%A.I had higher number of thrips. Thiachloprid treated plots had the lowest number of *M. sjostedti* but the number of *F. occidentalis* was marginally affected by this pesticide in the two plantings.

Previous studies by Kasina et al., (2006) and Michalik et al., (2006) observed that flower thrips can be managed by some pesticides in such as Fipronil ,Spinosad andMethiocarb in legumes . Another work by Oparaek et al. (2006) in Nigeria observed that when cowpeas are sprayed with 20% African black pepper extract *Piper guineense* four time in a week, the population of bud flower thrips (*M. sjostedti* T.) was significantly reduced. In Kenya Kasina et al. (2006) observed that a pesticide Methiocarb (Mesurol) significantly reduced the number of thrips in French bean crops. From this study it can be inferred that Azadirachtin 0.15% A.I and Chloropyriphos spray combination can be incorporated in the Integrated Pest Management of flower thrips in Snap beans.

6.1 Conclusions and recommendations

The following conclusions could be made from the results of this study,

(a) Snap bean crop could be intercropped or margin cropped with *Zea mays* in order to reduce flower thrips manifestation;

(b) Azadirachtin 0.15% A.I and Chloropyriphos should be applied on the growing Snap bean crops on weekly bases to reduce flower thrips;
(c) Thiacloprid should be applied during the early flowering of snap bean crop to minimize *M. sjostedti* and then stopped thereafter because of Maximum Residue Levels (M.L.S) and pre-harvest intervals.

The following are the main recommendations;

(a) Future studies should evaluate the effectiveness of combining *Zea mays* intercrop and pesticide application in suppressing flower thrips

(b) Optimum rates, interval of spraying pesticides and frequency of application in thrips management should be determined.

(c) These findings could be very useful to small holders Snap bean farmers in order to reduce the cost of production of snap bean pod. Some farmer field could be used for the technology transfer.
6.2 References

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