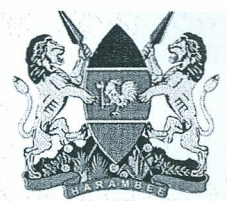




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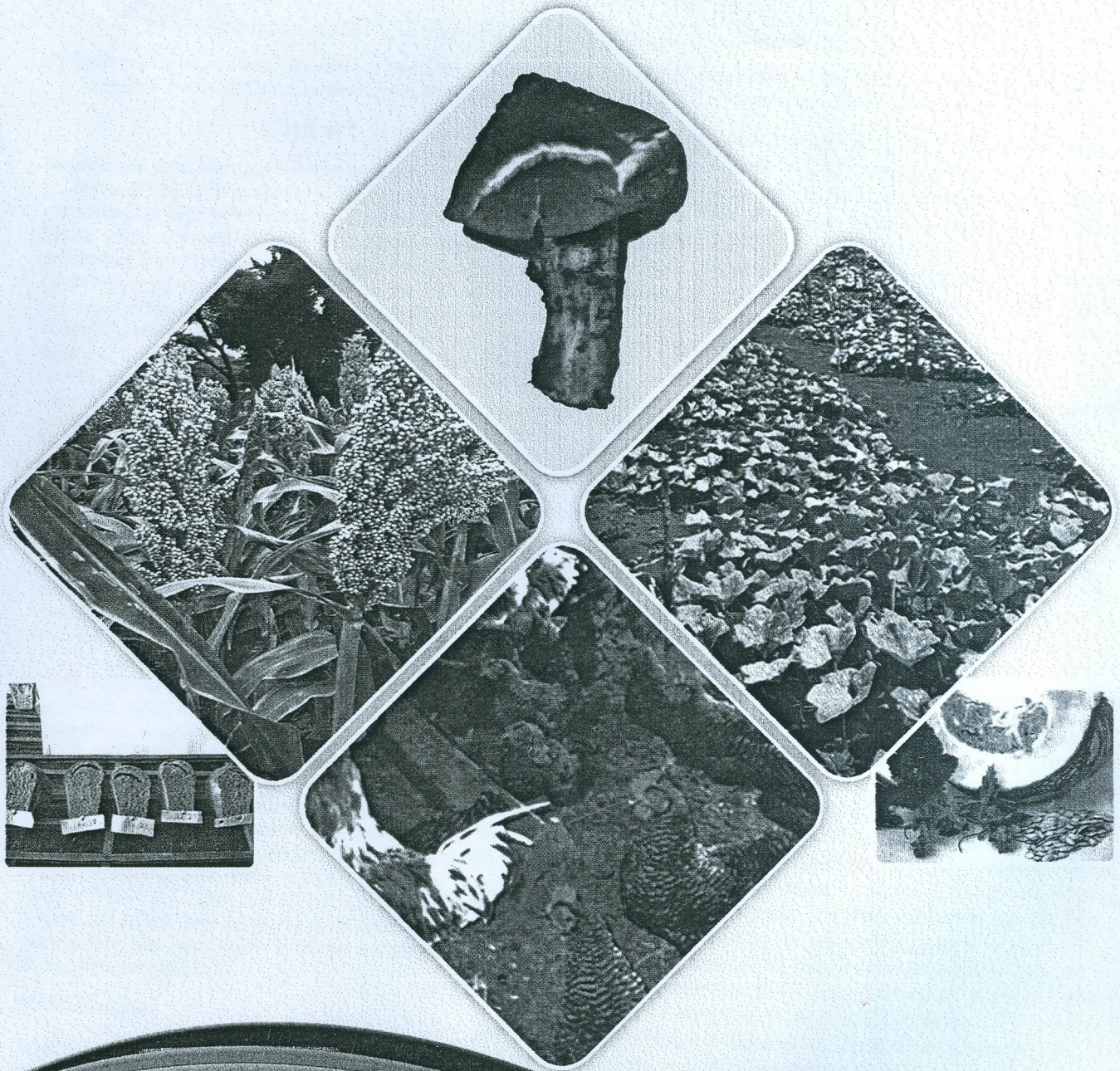


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# Enhancing Agricultural Productivity and Incomes through Research Partnerships, Technologies and Innovations for Sustainable Development



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# Effects of companion crops on population dynamics of maize lethal necrosis disease vectors in Bomet County, Kenya

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## Abstract

Maize is the most consumed staple food crop in Kenya with a per capita of 110 kg. It is equally an important commercial crop particularly in high potential areas. Currently, the presence of Maize lethal necrosis disease (MLND) has constrained its production. The disease is challenging to manage because it is a co-infection of maize by two viruses, the Maize chlorotic mottle virus and Sugarcane mosaic virus, which are vectored mainly by corn thrips (*Frankliniella Williamsi*) and corn leaf aphids (*Rhopalosiphum maidis*), respectively. This study was carried out to assess the potential for companion crops to act as traps or repellents for these vectors, thus contributing to vector management. Trials were carried out in farmers' fields in Bomet County. Treatments included Napier, coriander, millet, sorghum and maize, arranged in a randomized complete block design with four replicates for two seasons, November 2014-April 2015 and April-August 2015. Each crop was planted either as an intercrop or a border crop with maize as the main crop. We present results from the first season. There were significant differences ( $P < 0.001$ ) in the presence of corn Thrips among the companion crops although intercrops (21.53) recorded a slightly higher significant figure than border crops (10.28). Coriander trapped the highest number of corn thrips (27.6), followed by sorghum (22.2). Napier and millet trapped the lowest mean number of thrips, 9.1 and 4.7, respectively. However, in comparison with maize (85.96), companion crops had significantly lower corn thrips. Coriander hosted the highest number of aphids (132.6) compared with Napier (45.9) and sorghum (30.8) while millet recorded the lowest (5.6). The number of aphids in coriander and maize (60.4) was not significantly different from each other but was significantly higher compared with those registered in other companion crops ( $P = 0.0021$ ). This preliminary study shows that both Napier and millet may act as repellent crops for Corn Thrips mainly as border crops while coriander and sorghum could act as trap crops majorly as intercrops.

## Introduction

Maize is an important staple food crop in Kenya with per capita consumption estimated at 98 kg per annum (Groote *et al.*, 2011). It is both a food security crop as well as a commercial crop in various parts of the country (Olwande, 2012). According to the Global information Network report (GIEWS, 2013), maize production in 2013 declined by more than 100, 000 metric tons from the previous year. This was a deficit of about 600,000

metric tons, which would be imported from Tanzania, Uganda and Zambia. The estimated decrease in maize production was due to various constraints key among them the Maize Lethal Necrosis Disease (MLND) (KALRO, 2012). Maize Chlorotic Mottle Virus (MCMV) co-infects maize with any of the following potyviridae virus such as Sugarcane Mosaic Virus (SCMV), Maize Dwarf Mosaic Virus (MDMV) or Wheat Streak Mosaic Virus (WSMV) to cause MLND (Wangai *et al.*, 2012; Uyemoto *et al.*, 1981; Niblett and Calfin, 1978). It was first reported in Bomet County of Kenya in September 2011 as well as Naivasha. In Kenya, MCMV combines with SCMV to cause MLND, which has caused extensive serious yield losses that led to complete yield loss (Wangai *et al.*, 2012). The effect of this disease has been devastating especially at the household levels where yield losses of 50% to 90% (Wangai *et al.*, 2012; Uyemoto *et al.*, 1980) have been reported. The disease has been reported in Uganda and Tanzania (Makumbi and Wangai, 2013) as well as Rwanda (Adams *et al.*, 2014) and South Sudan (Rumsey *et al.*, 2014 unpublished data).

The control of MLND poses serious difficulties due to the co-infection by two viruses. Chemical control measures have been undertaken to control the vectors that transmit the MCMV and SCMV with a 50% success (Miano and Kibaki, 2013). However, chemical implications in the environment have necessitated other intervention measures to be considered. Utilizing the plant cues to manage pests has become common due to reported successes with the highly promoted push-pull strategy for managing maize stem borers (Khan *et al.*, 2014). Intercrops have been known to control other species of thrips such as *Frankliniella occidentalis* on French beans (Kasina *et al.*, 2006, Nyasani *et al.*, 2012) but little is known on their role in the control of Corn thrips *F. williamsi* and corn leaf aphids (*Rhopalosiphum maidis*). When French beans are intercropped with Irish potatoes and sunflower, the intercrops are able to support the highest number of the of thrips while mono crops registers the least number (Nyasani *et al.*, 2012; Ramert *et al.*, 2002). Poly cropping has been known to create a microclimate that favours natural enemies (Munyuli *et*

et al., 2007). Generally intercropping results in lower levels of pests as compared to monocrops (Finckh and Karpenstein-Machan, 2002) as a result of mixed signals from the mixed crop volatiles, which help disorient the pests from accessing the target crop. The Push and Pull strategy also uses border crops of attractive trap plants (Zhengqun *et al.*, 2013). Stemborer moths were effectively repelled away from the maize crop (push) by *Desmodium* and molasses grass, and they were subsequently attracted (or trapped) to (pull) by the Napier grass and Sudan grass which emit the green leaf volatiles (Khan *et al.*, 2014). Therefore this study focused on two aspects of companion crops tested as border and intercrops: their potential to attract corn thrips and corn leaf aphids or repel these pests. Both these action would lead to reduced vector infestation of maize and therefore has potential to lower disease spread in a farm.

## Materials and Methods

### Study site

Studies were conducted at farmer fields in Longisa, Bomet County. The area lies at an altitude of 1900- 2100 m above sea level with bimodal rainfall pattern 1200 mm-1400 mm throughout the year (Jones, 2012). The long rainfall season is between March to September while the short rain season is between November and February (Jaetzold and Schmidt, 1982). The maximum temperature is 28-32°C with minimum of 13°C (Jaetzold and Schmidt, 1982).

### Study design

Randomized complete block design with 4 replicates was used. Plots measured 7.5 x 5.25 m. Treatments included: 1). maize monocrop (var. Olerai 500-22A0, 2) Napier border ,3) Napier intercrop, 4) sorghum border, 5) Sorghum intercrop,6) Coriander border,7) Coriander intercrop,8) Intercrop of Olerai 500-22A and DH 614 maize varieties,9) Intercrop of DK 8031, Olerai 500-22A and DH 614 maize,10) Pearl millet border , and 11) Pearl millet intercrop. Border crops and the outer lines of the intercrop were planted 2 weeks earlier while the inner lines of intercrops were planted same time with maize. Intra row spacing was 25 cm for maize, 20 cm for sorghum, and 15 cm for pearl millet 75 cm for Napier and 10 cm for coriander while Inter row spacing was 75 cm. Two plants were destructively sampled per plot and taken to the laboratory for specimen analysis. This was done up to 10 weeks after plant emergence. All plots were sampled for MLND and severity based on the following scale:1- no symptoms seen on leaves, 2- very mild chlorotic mottling on 1-2 leaves or flecking on less than 50% of leaves without generalized chlorosis, 3--Mild chlorotic mottling on 3 or more leaves or flecking on more than 50% of leaves without generalized chlorosis, 4-Chlorotic mottling on less than 50% of leaves accompanied by necrosis on 1-2 leaves or severe chlorotic mottling on more than 50% of leaves but without necrosis and 5-Severe chlorotic mottling on more than 50% of leaves accompanied by necrosis on 3 or more leaves. MLND severity scoring on the ears whereas follows; 1- no symptoms seen on bracts, 2-.very mild

'bleached appearance' on bracts, covering less than 50% of the surface but without necrosis, 3-mild 'bleached appearance' on bracts, covering more than 50% of the surface but without necrosis, - 4-severe 'bleached appearance' or browning on bracts, accompanied by necrosis on less than 50 % of the surface and 5- severe 'bleached appearance' on bracts, accompanied by necrosis on more than 50% of the surface.

### Data Analyses

Data were analysed using GenStat 17<sup>th</sup> edition. Analysis of variance for various variables across the treatments was performed at 95% level of confidence limit. Where applicable data was normalised by log (base 10) transformation (i.e. log<sub>10</sub> (x +1) and means separated by Fishers protected Least Significance difference test (LSD).

## Results and Discussion

### 1) Presence of corn thrips and corn leaf Aphids on companion crops

There were significant differences in the presence of corn thrips on companion crops (Table 1). Maize mono crop had the highest corn thrips as expected since it is the main host. This confirms maize as the preferred host for this pest/vector. Napier had the lowest corn thrips followed by millet and sorghum while coriander had the highest. Although results show coriander harbouring the vector more than the rest, it is important to confirm the presence of the MCMV on these hosts, to probably determine which can keep the virus in the absence of maize. This is because thrips semi persistently transmits MCMV by acquiring it from infected plants and inoculates it to healthy plants (Cabanas *et al.*, 2013). Since the thrips transmit MCMV immediately after acquisition and can only retain the virus for a few days without latent periods (Chen *et al.*, 2011, Uzetet *et al.*, 2011), the transmission mechanism is possibly interfered with as the vector feeds on non-host companion crops of MCMV. Presence of corn leaf aphids on the companion crops was also significantly different. Millet recorded the lowest while coriander recorded the highest, even higher than maize mono crop. Since aphids transmits SCMV non-persistently (Gwendolyne *et al.*, 1996), it is possible to disrupt virus transmission to maize if these aphids land on the companion crops and feed before infesting maize.

**Table 1. Mean number of Corn Thrips and Corn leaf aphids recorded on companion crops**

Companion crop	Corn thrips	Corn leaf aphids
Napier	4.69 ± 0.110 a	45.88± 0.229 ab
Millet	9.13± 0.143 ab	5.63 a± 0.138a
Coriander	27.62± 0.178 b c	132.62± 0.249 c
Sorghum	22.19 ± 0.156 a b	30.75±0.201 a <sub>b</sub>
Mono crop	85.96± 0.182c	60.38± 0.182bc
<i>P- value</i>	<i>&lt; 0.001</i>	<i>0.0021</i>

*NB: Means within column followed by the same letter are not significantly different (P = 0.05).*

There were statistically different infestation levels of corn thrips on companion crops when grown either as

border or intercrop ( $P < 0.001$ , Table 2). Highest infestation was on maize grown as mono crop, inter variety planting and as mixed crop respectively. Border cropping system resulted to lower presence of corn thrips on the companion crops compared with intercrop. This shows that border crops could act more as repellent crop than as trap crop. All the maize varieties look similar visually and may also have similar chemical stimuli leading to attraction of more thrips than the other systems (Parker *et al.*, 2013). It is however noted that an intercrop variety of Olerai and H614 registers a significantly lower number of thrips than the mixed crop. More studies are therefore required to determine whether Maize variety H614 has the potential to attract fewer vectors. Presence of corn leaf aphids on companion crops was not statistically different across the cropping systems. The different cropping system had no effect on the population of aphids. This could be attributed to the fact that leaf corn aphids are generalist herbivores that sometimes prefer diverse to simple plantings (Bach, 1980 and Andow, 1991) which become potentially different hosts that are all acceptable to the Aphids (Parker *et al.*, 2013).

**Table 2: Mean number of Corn thrips and Corn leaf aphids recorded on companion crops under different system of cropping**

Cropping system	Corn Thrips	Corn leaf Aphids
Border cropping	10.28 ± 0.109 <sup>a</sup>	47.72 ± 0.153
Inter cropping	21.53 ± 0.109 <sup>ab</sup>	59.72 ± 0.164
Maize mixed cropping-2	54.75 ± 0.214 <sup>bc</sup>	115.13 ± 0.386
Mono cropping	71.75 ± 0.351 <sup>c</sup>	43.38 ± 0.301
Maize mixed cropping-3	131.38 ± 0.384 <sup>c</sup>	22.62 ± 0.2872
<i>P- value</i>	<i>&lt; 0.001</i>	<i>0.816</i>

*NB: Means within column followed by the same superscript are not significantly different ( $P = 0.05$ ).*

There was no effect on the populations of aphids when different companion crops were planted with maize as borders or intercrops ( $P = 0.215$ , Table 3). The polyphagous behaviour of aphids enables them to colonise every companion crop in every cropping system without discrimination. According to Potting *et al.* (2007), the results could also be due to the small size of aphids making them to be passively transported by wind currents resulting to limited host detection ability. This behaviour could give an advantage to the main maize host by reducing the chances of SCMV interacting with MCMV to give rise to MLND. The less the SCMV manifests itself on maize, the fewer the chances of MLND occurring.

Companion crops planted as border or intercrops with maize had a significant effect on the population of *F. williamsi* ( $P = 0.013$ , Table 3). Napier and sorghum border registered significantly lower numbers of *F. williamsi* as compared to the rest of the treatments. They were closely followed by sorghum border, millet border and millet intercrop that registered a significantly higher number of thrips although they didn't differ with the Napier and sorghum border. These results gives the

indication that millet, sorghum and Napier could be used as repel companion crops probably disrupting the normal chain of host crop selecting behaviours (Finch *et al.*, 2003). A combination of the three varieties of maize Olerai, H614 and DK 8031 had a significantly higher number of *F. williamsi* as compared to Olerai alone and Olerai combined with H614. From these results, *F. williamsi* significantly prefers maize to the companion crops although coriander as a border or intercrop of maize significantly registers higher numbers of Thrips as compared to other trap crops. Therefore, Coriander has the ability? to be a good trap crop for the thrips. However more tests should be carried out to monitor the population build-up of the thrips throughout the growing season and relate it with the MLND manifestation in maize crops. Further studies are also required to determine whether coriander is a host to *F. williamsi* or a dead end trap crop that only offers oviposition sites but may not be able to support the development of the pest.

## 2) Population of the vectors on maize protected by companion crops under different cropping system

There was no significant difference in the number of *F. williamsi* and Aphids sampled on maize variety Olerai (Table 4). The MLND scale in all treatments did not differ significantly (Fig, 4) however it will be important to monitor the crop from germination up to harvest to check the development levels of MLND throughout the cropping system. This is the first report on comparison of vectors of MLND viruses in different companion crops and the various cropping systems. There is need therefore to carry out more studies on other possible trap crops and stabilising the cropping systems so that a clear definite ratio can be used.

**Table 3. Mean number of Corn Thrips and Corn leaf Aphids in different cropping systems on companion crops**

Treatment	Corn Thrips	Corn leaf Aphids
Napier border	3.9 ± 0.18 <sup>a</sup>	32.00 ± 0.30
Sorghum border	4.1 ± 0.14 <sup>ab</sup>	8.00 ± 0.23
Napier intercrop	5.5 ± 0.13 <sup>ab</sup>	60.00 ± 0.37
Millet border	9.0 ± 0.22 <sup>ab</sup>	7.00 ± 0.21
Millet Intercrop	9.3 ± 0.20 <sup>abc</sup>	4.00 ± 0.19
Coriander Intercrop	20.3 ± 0.19 <sup>abcd</sup>	122.00 ± 0.33
Coriander border	24.1 ± 0.26 <sup>abcd</sup>	144.00 ± 0.40
Sorghum Intercrop	51.1 ± 0.32 <sup>a, c</sup>	54.00 ± 0.33
Olerai+614+DK	131.4 ± 0.38 <sup>d</sup>	23.00 ± 0.40
Olerai +614	54.75 ± 0.35 <sup>bcd</sup>	115.1 ± 0.33
Olerai	71.75 ± 0.21 <sup>d</sup>	43.28 ± 0.29
<i>P- value</i>	<i>0.013</i>	<i>0.215</i>
<i>LSD - value</i>	<i>0.703</i>	<i>0.872</i>

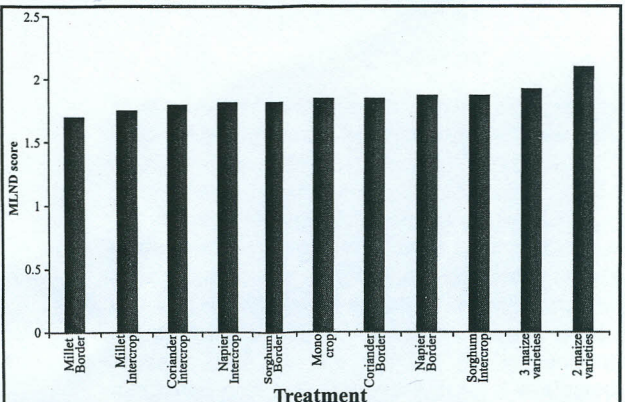
*NB: Means within column followed by the same letter are not significantly different ( $P = 0.05$ ).*

**Table 4. Mean number of Thrips and Aphids in different Treatment of cropping systems**

Treatment	Corn Thrips	Corn leaf aphids
Maize Olerai	14.80 ± 0.11	6.05 ± 0.19
Napier border	25.95 ± 0.11	13.35 ± 0.18
Napier intercrop	9.50 ± 0.10	3.45 ± 0.14
Sorghum border	19.85 ± 0.09	12.90 ± 0.17
Sorghum intercrop	17.90 ± 0.12	8.35 ± 0.16
Coriander border	14.65 ± 0.12	6.85 ± 0.16
Coriander intercrop	18.80 ± 0.11	12.70 ± 0.19
Olerai+614	18.55 ± 0.14	10.00 ± 0.17
Olerai+614+DK	33.15 ± 0.15	15.15 ± 0.16
Millet border	14.50 ± 0.09	16.65 ± 0.17
Millet intercrop	11.05 ± 0.09	6.05 ± 0.17
<i>P-value</i>	<b>0.329</b>	<b>0.318</b>
<i>LSD value</i>	<b>0.315</b>	<b>0.466</b>

**Conclusion**

Coriander may turn out to be a good trap crop for the *F. williamsi* and Aphids. However more tests should be carried out to monitor the population build-up of the thrips throughout the growing season and relate it with the MLND manifestation in maize crops. Sorghum intercrop has more potential in as a trap crop for *F. williamsi* while millet, Napier and sorghum border has more potential as repel companion crops. From this study mixed maize varieties of Olerai, H 614 and DK 8031 attracts more *F. williamsi* than any other combination hence farmers should be advised against mixing varieties.



**Figure 1. MLND severity scores on the main crop under various treatment**

**Recommendations**

Studies are required to determine whether coriander is a host to Corn Thrips or a dead end trap crop that only offers oviposition sites but may not be able to support the development of the pest. There is need therefore to carry out more studies on other possible trap crops and stabilising the cropping systems so that a clear definite ratio can be used

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# Management of snap bean pests by intergrating seed dressing, foliar sprays and intercropping with maize

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## Abstract

Insect pests remain a major constraint in the production of snap beans and farmers mainly rely on chemical pesticides to manage the insect pests and diseases. However, the introduction of maximum residue levels (MRLs) for export vegetables by European markets pose a challenge to the use of pesticides. This study was carried out to develop sustainable options of managing snap bean pests and reducing chemical residues on snap bean produce. Field experiments were carried out in farmers' fields in Mwea and Embu from July 2013 to January 2014 for two planting cycles under irrigation. The integrated pest management strategies evaluated included: i) seed dressing only, ii) seed dressing followed by three neem sprays, iii) seed dressing followed by two pyrethrin sprays and one neem spray, iv) seed dressing followed by three pyrethrin sprays and intercropping snap bean with maize, v) seed dressing followed by two pyrethrin sprays plus one spray with a biological product, vi) seed dressing followed by two neem sprays plus one spray with a biological product, and vii) two pyrethrin sprays and one neem spray only. The data collected included: emergence, plant stand, nodulation, thrips population, bean stem maggot population, whitefly population, bean yield and pest damage. The combination of seed dressing, two pyrethrin sprays and neem applied at the vegetative stage, early flowering and early podding reduced white fly and thrips population by up to 54% and 60% respectively. Similar results were also observed on plots where seeds dressing was done before planting combined with intercropping with maize plus three pyrethrin sprays at the vegetative stage, early flowering and early podding. Seed dressing had a direct effect on the bean

stem maggots that attack the seedling at a very young stage. Spraying with pyrethrin sprays had a quick knockdown effect on the population of whitefly and thrips while the maize intercrop also reduced the pest population. These options also reduced pod damage due to thrips by up to 75 and 93% and increased yield of extra-fine to thrips by up to 157 and 162% and pods by up to 148 and 133%. The results showed that seed dressing followed by two pyrethrin sprays at the vegetative stage and early flowering stage plus a single spray with Nimbecidine at early podding, sprays and intercropping with maize were effective in managing snap bean pests. This demonstrates that integrated pest management options would be viable alternatives to chemical pesticides thereby enabling farmers meet the strict maximum chemical residue level requirements set by European consumers.

**Key words:** *Phaseolus vulgaris* L, seed dressing, bio-pesticides, intercropping, integrated pest management

## Introduction

Snap bean (*Phaseolus vulgaris* L.) is grown specifically for the immature green pods primarily for export market to European Union and elite local urban markets (Infonet-Biovision, 2014). The production of snap bean, one of Kenya's most important export vegetable crops, is steadily rising (HCDA, 2013). Snap beans from Kenya are exported to United Kingdom, France, Holland, Germany, United Arab Emirates and South Africa (HCDA, 2013). Local consumption of snap beans has also increased over the last few years, providing a domestic market (HCDA, 2013). Snap bean production