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# Potentiality of field margin with insecticidal plants in the reduction of insect pests' damage in common bean production, Northern Tanzania

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**Key words:** *Ocimum suave*, Incidence, Insect pests, Severity.

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## Abstract

A study was conducted to evaluate the effects of four different insecticidal plants (*Dysphania ambrosoides, Hyptis Suavelons, Sphaeranthus suaveleons* and *Ocimum suave)* in reducing pest abundance and damage in common bean under field conditions in Moshi, Tanzania. The experiment was laid out using a randomized complete block design (RCBD) with five (5) replications. Results indicated that the marginal insecticidal plants reduced insect pest abundance significantly ($p<0.001$) compared with the control plots without the field margin plants. Results for pest infestation indicated that there was a significant ($p<0.001$) difference in incidence and severity of insect pest from 2nd to 8th week on common bean growth. The highest overall pest's incidence (78%) and severity (5.00) were observed in the control treatment compared with those recorded in plots surrounded by inscectidal plants. Overall, the lowest incidence and severity were recorded in plots surrounded by *O.suave* (3.4% and 0.200) and *S.suaveleons* (4.8% and 0.400). Based on these results, field margins with inscectidal plants particularly *O.suave* and *S.suaveleons* are recommended in bean production in Tanzania. Further research is recommended on exploring these insecticidal plants for possible application on the same and other crop systems in different agro-ecological regions of Tanzania.

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**Introduction**

Tanzania is ranked amongst the top twenty common bean (*Phaseolus vulgaris L.*) producing countries in the world and the second in sub-Saharan Africa after Kenya (Hillocks *et al.*, 2006; Mkenda *et al.*, 2014). Common beans are largely cultivated in northern, west and southern highland regions of Tanzania(Hillocks *et al.*, 2006; Mwanauta *et al.*, 2015) . In this country, common beans are main source of dietary protein, calories, dietary fibers, and also minerals such as calcium, copper, magnesium, manganese, iron, and zinc and many micronutrients and phytochemicals which are key elements for mental development and source of income and nutrition for producers (Tryphone *et al.*, 2013).

The predicted annual production of bean in Tanzania is about 300, 000 tones, meaning 82% of the total production of pulses (Tryphone *et al.*, 2013) . Similarly, the estimated average production of common bean is 982.5 kg/ha which is lower compared with the potential yield production that ranges between 1500-3000 kg/ha(Hillocks *et al.*, 2006). This low output is attributed to many factors such as poor seed quality, poor performance of the local landraces, pests and diseases, low soil fertility, drought and poor crop management, like late weeding (Hillocks *et al.*, 2006). Of these, insect pests, bean stem maggot (*Ophiomyia phaseoli*), ootheca (*Ootheca bennigseni*) and aphids (*Aphis fabae*) have been identified as the main constraints of common bean production (Mwanauta *et al.*, 2015).

It has been reported that these insect pests are important factors for reduction in quality of common beans development and responsible for signified losses in yield (Getu, 2009; Mkenda *et al.*, 2014).

Synthetic pesticides have been used as the common method to control insect pests in bean fields. However, they have been reported to have various negative effects to beneficial insects, environment and human health (Raghavendra *et al.*, 2016; Moshi and Matoju, 2017). Due to the adverse effects of synthetic pesticides on beneficial insects that contribute a lot to agricultural production by providing ecosystem services such as pollination and natural control (Moshi and Matoju, 2017), environment and human health, there is an urgent need to control insect pests in sustainable way in agricultural landscape without affecting beneficial insects, environment and human health.

One of the methods that have been used to control insect pest in sustainable manner without affecting non-target insects (natural enemies and pollinators), environment and human health, is the use of natural habitat or field margin with flowering plants.

The presence of flowering plants in the field margins has been reported to facilitate the attraction of beneficial insects including natural enemies and pollinators by providing pollen, alternative prey, nectar and shelter which may favor their survival in the fields (Landis *et al.*, 2000; Amaral *et al.*, 2013; Blaauw and Isaacs, 2015).

Natural enemies such as ladybirds, spiders, lacewings and hoverflies use nectar and pollen to during their different life stages (Wäckers *et al.*, 2008; Lu *et al.*, 2014; Mansion-Vaquié *et al.*, 2017). The availability of nectar sources and other carbohydrate in field margin play a big role in the longevity and fecundity of parasitoids(Baggen and Gurr, 1998; Siekmann *et al.*, 2001), and may increase the effectiveness of natural enemies in controlling insect population in crop fields (Géneau *et al.*, 2012; Jamont *et al.*, 2014; Bischoff *et al.*, 2016). For instance, natural enemies such as chrysopids, coccinellids, and syrphids are known to use nectar to enable them move from field margin to crop fields to control insect pests in crop fields (Bianchi *et al.*, 2006).

Although this methodology has managed to recover ecosystem services in agriculture production, it has been blamed to harbor also insect pests which may later on destroy crop in the field. Therefore, there is a need to develop other approaches which can be used to maintain biological control in agricultural production without harboring insect pests.

The use of field margin with insecticidal plants can be a better alternative to solve the problems of pests while maintaining ecosystem services such as pollination and biological control because insecticidal plants have the capacity to repel insect pests and attract natural enemies in the crop fields (Khan *et al*., 2008; Mkindi *et al*., 2015).. *Dysphania ambrosoides, Hyptis Suavelons, Sphaeranthus suaveleons* and *Ocimum suave* were considered as medicinal plants traditionally in previous years implying that they have bioactive compounds which are capable to fight against pathogen, bacteria and fungi (Ávila-Blanco *et al*., 2014; Tibyangye *et al*., 2015; Kebede *et al*., 2017). Therefore this research study was designed to assess the effects of annual field margins with insecticidal plants; *Dysphania ambrosoides, Hyptis Suavelons, Sphaeranthus suaveleons* and *Ocimum suave* in controlling insect pests and reduction of pest infestation in common bean crops.

**Materials and methods**

*Study area*

The study was conducted at Tanzania Coffee Research Institute (TaCRI) farm in Moshi, Northern Tanzania. The site is located at latitude 3°13'59.59"S and longitude 37°14'54"E respectively, with an altitude of 1268m above sea level. The area receives mean annual rainfall of about 1200 mm and mean annual temperature of about 18 °C.

*Study materials*

Seeds of common beans (Lyamungo 90 variety) used for the study were sourced from TARI-Selian Research Center in Arusha. Additionally, insecticidal plant seedlings (*Dysphania Ambrosoides, Ocimum suave* and *Hyptis suaveleons, sphaeranthus Indicus*) were obtained from farmers' fields in Kibosho-Kirima and TaCRI farm in Kilimanjaro region, Tanzania.

*Experimental design and Seedlings Growth*

The study was carried out during the rainy season from March to August 2018 which is the main bean cropping season in the study area. Field preparation involving ploughing and harrowing was done in March before planting insecticidal plants at the margin of the plots and beans as well. Similarly, the collected insecticidal plant seedlings were grown in a nursery for 14 days then transplanted in the experimental plots. After land preparation activities, insecticidal plants were transplanted at the border of each plot spaced at 20cm apart two weeks before planting beans so as flowering to occur at the same time with beans. Experimental plots of 5 m × 5 m were prepared with 15 m apart, making a total of twenty five plots.

The experiment was laid out using a randomized complete block design (RCBD) with five (5) treatments each replicated five times. Two seeds of common bean (Lyamungo 90 variety) were planted at a spacing of 20 cm within rows and 50 cm between rows. DAP (as source of phosphorous) was applied (4 grams) per hole due to the fact that the phosphorous levels in the study area was below optimal level to support plant growth.

*Data collection*

Assessment of insect pests' damage level in common bean plots surrounded by insecticidal plants were done through recording incidence and severity of damage by insect pests to the common bean plants after every two weeks from the 4$^{th}$ to 10$^{th}$ week after setting the experiment. Four plants from three middle rows inside the 25 m square block were randomly selected from the center of the plot and observed to record the number of plants infested by insect pests. An entire plant was inspected by visual (eye) observation to record the number of plants infested by insect pests. Plant infestation assessment was based on the damaged bean leaves. The abundance of aphids was assessed using scoring scale from 0 to 5 as per Mkenda *et al. (2014)*, where 0= none, 1 = A few scattered individuals, 2 = a few isolated colonies, 3 = Several isolated colonies, 4 = Large isolated colonies and 5 = Large continuous colonies.

The incidence was in terms of percentage basing on the number of leaves damaged per selected plants, while severity or extent/level of damage was scored as follows: 0= no visible damage; 1=1-5% damage; 2=6-

25% damage; 3=26-50% damage; 4=51-75% damage; 5=76-100% damage (Mkenda *et al.*, 2014).

*Data analysis*

The data obtained (pest abundance, incidence and severity of pest foliage damage) were analyzed using Genstat (15th Version) statistical package (VSN International Ltd). One Way Analysis of variance (ANOVA) was performed to test the effectiveness of field margins with insecticidal plants on pest abundance and reduction of pest incidences and severities of the common bean foliage pest damage. Mean separation of the treatments was done by Tukey's test at probability level of 0.05.

**Results**

*Effects of field margins with insecticidal plants on the pest abundance in common bean at the second week after planting*

The results indicate that there was a significant (P≤0.001) difference in insect pest abundance across the treatments at 2nd week after planting common beans. Aphids, Leaf hopper, Blister beetle, Caterpillar, Grass hopper and *Ootheca* were the insect pests observed at this period of common bean growth in all treatments. Field margins with insecticidal plants had few number of pest compared with the control. *Ocimum suave* and *Sphaeranthus* were so effective in repelling Blister beetles (0.400) (Table 1).

**Table 1.** Effects of field margins with insecticidal plants on the pest abundance in common bean at the second week after planting.

| Treatment | Aphid | Leaf hopper | Blister beetle | Caterpillar | Grass hopper | *Ootheca* |
|---|---|---|---|---|---|---|
| *Ocimum suave* | 1.000a | 1.400a | 0.400a | 0.600a | 1.000a | 0.800a |
| *Sphaeranthus suaveleons* | 1.000a | 5.600b | 0.400a | 4.000b | 1.600ab | 6.400b |
| *Hyptis suaveleons* | 1.000a | 6.000bc | 1.000ab | 4.800bc | 1.600ab | 7.600b |
| *Dysphania ambrosoides* | 1.400a | 6.600c | 1.600bc | 4.800bc | 2.000b | 8.000b |
| Control | 3.200b | 9.600d | 2.600c | 6.200c | 5.600c | 11.800c |
| Grand mean | 1.52 | 5.84 | 1.20 | 4.08 | 2.36 | 6.92 |
| LSD | 0.417 | 0.545 | 0.703 | 1.047 | 0.584 | 1.982 |
| P-Value | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

*Different letter(s) within the same column are significantly different at *p=0.05* as determined by Tukey's test.

*Effects of field margins with insecticidal plants on the pest abundance in common bean at the fourth week after planting*

The results revealed significant (P≤0.001) difference amongst the treatments at 4th week after planting common beans. The insect pests observed in all treatments at 4th week of bean growth were aphids, leaf hopper, blister beetle, grass hopper and *Ootheca*. Few insect pests were noted in the field margins with insecticidal plants than the control. *Ootheca* (0.400) and blister (0.400) were reduced considerably in *Ocimum suave* treatments (Table 2).

**Table 2.** Effects of field margins with insecticidal plants on the pest abundance in common bean at the fourth week after planting.

| Treatment | Aphid | Leaf hopper | Blister beetle | Caterpillar | Grass hopper | *Oetheca* |
|---|---|---|---|---|---|---|
| *Ocimum suave* | 0.600a | 0.700a | 0.400a | 0.500a | 0.600a | 0.400a |
| *Sphaeranthus suaveleons* | 1.000ab | 0.800a | 0.500a | 0.600a | 1.400ab | 1.500ab |
| *Hyptis suaveleons* | 1.000ab | 5.600b | 1.000ab | 3.600b | 1.800ab | 3.400b |
| *Dysphania ambrosoides* | 1.400b | 8.000c | 1.600b | 4.600b | 2.000b | 5.600c |
| Control | 4.000c | 12.400d | 6.400c | 7.400c | 7.400c | 10.400d |
| Grand mean | 1.62 | 5.71 | 2.04 | 3.46 | 2.67 | 4.38 |
| LSD | 0.470 | 1.134 | 0.780 | 0.848 | 0.765 | 0.731 |
| P-Value | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

Different letters within the same column are significantly different at *p= 0.05* as determined by Tukey's test.

*Effects of field margins with insecticidal plants on the pest abundance in common bean at the sixth week after planting*

The results indicate that, there was a significant (P≤0.001) difference across the treatments. Field margins with insecticidal plants considerably reduced number of insect pest compared with the control. Grass hoppers (0.0) were not found in *Ocimum suave* treatment (Table 3).

*Effects of field margins with insecticidal plants on the pest abundance in common bean at the eighth week after planting*

The results on the effects of field margins with insecticidal plants on the pest abundance in common bean at 8th week after planting show that, there was a significant (P≤0.001) difference in insect pest abundance between the treatments.

**Table 3.** Effects of field margins with insecticidal plants on the pest abundance in common bean at the sixth week after planting.

| Treatment | Aphid | Blister beetle | Caterpillar | Grass hopper | Leaf hopper | Flower beetle |
|---|---|---|---|---|---|---|
| *Ocimum suave* | 0.400a | 0.200a | 0.200a | 0.000a | 0.200a | 0.800a |
| *Sphaeranthus suaveleons* | 0.400a | 0.200a | 0.400a | 0.200a | 0.600a | 1.200a |
| *Hyptis suaveleons* | 0.600a | 0.200a | 0.400a | 0.200a | 0.600a | 1.600a |
| *Dysphania ambrosoides* | 0.800a | 0.200a | 0.600a | 0.400a | 0.800a | 1.600a |
| Control | 4.600b | 8.200b | 12.600b | 8.600b | 14.000b | 5.400b |
| Grand mean | 1.36 | 1.80 | 2.84 | 1.88 | 3.24 | 2.12 |
| LSD | 0.698 | 0.670 | 0.813 | 0.59 | 0.723 | 0.895 |
| P-Value | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

Different letters within the same column are significantly different at $p = 0.05$ as determined by Tukey's test.

The control was observed to harbor more insect pests while other treatments repelled insect pests. Aphid, blister beetle, caterpillar, grass hopper, leaf hopper were mostly repelled in *Ocimum suave* and *Sphaeranthus suaveleons* treatments (Table 4).

*Effects of field margin with insecticidal plants on incidence and severity of pest foliage damage in common bean*

The results on the effects of field margins with insecticidal plants on incidence and severity are presented in Table 5.

The results depict that there was a significant (P≤0.001) difference in incidence and severity from 2nd to 8th week of common bean growth. Generally, control treatment had highest incidence and severity insect pests assessed and was followed by *Dysphania ambrosoides*, Hyptis *suaveleons, Sphaeranthus suaveleons* and *Ocimum suave.*

**Table 4.** Effects of field margins with insecticidal plants on the pest abundance in common bean.

| Treatment | Aphid | Blister beetle | Caterpillar | Grass hopper | Leaf hopper | Flower beetle |
|---|---|---|---|---|---|---|
| *Ocimum suave* | 0.000a | 0.000a | 0.000a | 0.000a | 0.000a | 0.200a |
| *Sphaeranthus suaveleons* | 0.000a | 0.200a | 0.200a | 0.000a | 0.200a | 0.400a |
| *Hyptis suaveleons* | 0.200a | 0.400a | 0.200a | 0.200a | 0.200a | 0.400a |
| *Dysphania ambrosoides* | 1.200a | 0.400a | 0.200a | 0.200a | 0.200a | 1.600b |
| Control | 4.800b | 12.400b | 6.800b | 13.200b | 3.400b | 9.400c |
| Grand mean | 1.24 | 2.68 | 3.08 | 2.72 | 0.80 | 2.40 |
| LSD | 1.332 | 0.618 | 0.527 | 0.618 | 0.813 | 0.698 |
| P-Value | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

Different letters within the same column are significantly different at $p = 0.05$ as determined by Tukey's test.

The highest incidence (78.00) and severity (5.00) were observed in control at 8th week of common bean growth.

**Discussion**

The present findings indicated that at the early stage of common bean growth (2nd week) after planting, pest abundance, incidence, and severity of pest foliage damage were reduced in common beans surrounded by insecticidal plants compared with the control. Although there was a reduction of pest abundance, the incidence, and severity of pest foliage damage in beans which were surrounded by insecticidal plants at 2nd week after planting common beans, it was not comparable with the reduction which was observed in subsequent periods of common beans growth after planting (4th to 8th week). This may be due to the fact that at early stage of common bean growth, insecticidal plants in the field margins were also at their early stages of growth and had not reached their physiological maturity. Additionally, at this stage of common beans growth, insecticidal plants were at vegetative level implying that they were still developing. This findings are in agreement with the study by (Abreu *et al.*, 2004) who reported that at the initial stages, insecticidal plants emit little amount of bioactive compounds (10%). Therefore, bioactive compounds emitted at early stage were probably not enough to repel insect pests in common beans. This might be the reason why the pest abundance, incidence, and severity of foliage pest damage observed in beans which were surrounded by *Dysphania Ambrosoides, Hyptis Suavelons, Sphaeranthus suaveleons* and *Ocimum Suave* was higher at 2nd week compared with the other periods of common bean growth.

**Table 5.** Effects of selected field margin plants on incidence and severity of foliage damage.

| | 2nd week | | 4th week | | 6th week | | 8th week | |
|---|---|---|---|---|---|---|---|---|
| | Incidence | Severity | Incidence | Severity | Incidence | Severity | Incidence | Severity |
| Treatment | *Ootheca* | | Aphids | | Aphids | | Flower beetle | |
| *Ocimum suave* | 14.000a | 1.000a | 8.800a | 0.600a | 6.200a | 0.400a | 3.400a | 0.200a |
| *Sphaeranthus suaveleons* | 18.000ab | 1.200a | 9.000ab | 0.800a | 7.200a | 0.600a | 4.800ab | 0.400a |
| *Hyptis suaveleons* | 19.000ab | 1.400a | 10.000bc | 1.200a | 7.600a | 0.600a | 5.600ab | 0.400a |
| *Dysphania ambrosoides* | 23.000b | 1.600a | 12.000c | 1.200a | 8.600a | 0.800a | 6.600b | 0.600a |
| Control | 58.000c | 3.000b | 61.600d | 3.400b | 72.000b | 4.000b | 78.000c | 5.000b |
| Grand mean | 26.40 | 1.64 | 20.28 | 1.44 | 18.64 | 1.28 | 19.68 | 1.32 |
| LSD | 5.300 | 0.520 | 1.866 | 0.646 | 0.580 | 0.610 | 0.173 | 0.610 |
| P-value | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

Different letters within the same column are significantly different at $p= 0.05$ as determined by Tukey's test.

During the 4th to 8th week of bean growth, pest abundance, incidence, and severity were reduced considerably with time in common beans which were surrounded by field margins with insecticidal plants while increasing in the control. The decrease of pest abundance, incidence and severity can be explained by the fact that from 4th to 8th week, insecticidal plants were well grown and adapted to the study area. Furthermore, the field margin plants were at flowering stage implying that they were capable of emitting enough bioactive compounds to repel insect pests and attract a good number of natural enemies in the beans crops resulting in substantial reduction of insect pest damage of common bean foliage (Abreu *et al.*, 2004; Figueiredo *et al.*, 2008).

From study findings, *Ocimum suave* performed better in reducing insect pest abundance and their damage compared to other insecticidal plants. This was probably due to the facts that the bioactive found in this plant were very effective in repelling insect pest compared to other secondary metabolites found in other plants assessed in this study. This findings are similar to Chogo and Crank (1981) who reported that eugonol was the most effective bioactive compounds repelled the insects.

In contrast, in the control the pest abundance, incidence and severity of bean foliage pest damage were increased with growth-time of common bean. This suggests that as the common beans were growing, the number of insect pests that fed on leaves and flowers were also increasing considerably. This was due to the fact that, in the control there was no insecticide applied to control insect pests. This may be the reason to have higher pest abundance, incidence and severity of bean foliage damage in the control plot compared with other treatments.

## Conclusion

This study has revealed that field margin with insecticidal plants are effective in reducing pest abundance, incidence and severity of foliage pest damage in common bean production. All field margins with insecticidal plants were observed to reduce considerably pest abundance, incidence and severity of foliage damage in bean production compared with other treatments. Considering the study findings on the reduction of pest abundance, incidence and severity of foliage damage, we thus conclude that the use of *Dysphania Ambrosoides, Hyptis Suavelons, Ocimum Suave* and *Sphaeranthus suaveleons* as field margin plants reduced the insect pest population and their infestations in bean fields.

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