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Influences of Cultural Practices against Sweet Potato Weevil (*Cylas puncticollis* Boheman) (Coleoptera: Brentidae) in Wolaita Zone of Southern Ethiopia

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Abstract
*Sweet potato weevil (*Cylas puncticollis *Boheman) one of the most devastating menace to sweet potato production in southern Ethiopia. Two noxious plants, namely* Lantana camara *and* Melia azadirachta *along with Malathion 50%EC were arranged in a factorial RCBD with 18 treatment combinations and tested on variety* Temesgen, Awassa 83, *and Local cultivar under irrigated and non-irrigated schemes in 2014 off-season with the aim to manage sweet potato weevil through integrated means. ANOVA showed that the integration of* Temesgen *with* Melia azadirachta *in irrigated condition gave superior result with less infestation of weevil. Despite the highest infestation, both* Awassa83 *and Local variety gave the highest root weight, root length, root number/pl, and vine length. Hence, further researches are needed to be initiated on the use of noxious plants, watering, and varietal selection against sweet potato weevil.*

***Key words**: -* Cylas puncticollis, *IPM, Noxious plants*

Introduction

Sweet potato (*Ipomoea batatas* L.) is an important food security crop in east Africa [1, 2] in general and in southern Ethiopia [3], in particular. The region accounts for 95% of total production in the country [3]. The national average yield of sweet potato is extremely low (8.43 ton/ha) [4] as compared to 38 t/ha by other countries [5]. The sweet potato weevil (*Cylas puncticollis* Boheman) is one of the major biotic constraints [6, 7]. In many zones in southern Ethiopia, it has remained the most serious menace to the production of the crop. Except the sweet potato weevil (*Cylas puncticollis* Boheman), most of the insect pests' damage to sweet potato is often cosmetic and not yield reducing [8]. The sweet potato weevil larvae and adults feed on the roots, causing extensive damage, both in a field and storage. Weevil damage produces quantitative losses and aesthetically unappealing roots which may be discolored and have a bitter taste. The weevil also stimulates the production of phenolics compounds, leading to brown discoloration of the flesh [9]. In Ethiopia loses due to sweet potato weevil range from 20-75% [10], sometimes reaching 100% [11]. So far, crop rotation the commonly practiced method by growers to minimize sweet potato weevil attack [8]. Information on the management of sweet potato weevil using integrated cultural means is still lacking. Hence, this research was initiated aim to control sweet potato weevil by using a combination of non-pesticidal, obtainable and cheap cultural methods.

Materials and Methods

Study Area, Experimental Design and Treatments

The experiment was conducted prior to the onset of the 2014 on-season, on the *Mante Gerrera* kebelle FTC Farm, Wolayita Zone, SNNP region. This area is thought to be one of the utmost infestation sites of this particular weevil. It is located 09^{o} 21 N and 40^{o} 12E with an altitude of 1740 masl. The mean annual rainfall is 1064 mm and mean minimum and maximum temperatures are 22^{o}C and 38^{o}C respectively. Three varieties, namely, *Awassa 83, Temesgen* and local variety had been applied on extracts of *M. azadirachta* , *Lantana camara*, and control (Malathion 50% EC) in irrigated & non-irrigated (control) conditions, arranged in a factorial experiment with RCBD design [(Plot area = 2.4m x 3.1m)] + [1.5m(gangway) x 4 = 6m] = Totally, 13.44m x 62.2m = 835.97 m^{2}).

Preparation and Extraction of Plant Materials

The leaves, stems and seeds of *Melia azadirachta,* and *Lantana camara* had been collected, sterilized, sun-dried and grounded. The aqueous extracts was prepared in 10gm/500ml (w/v) of water and shaken in well for 1 hour. The mixture was allowed to stand for 48 hrs and filtered using cheese cloth followed by filter paper (Whitman No. 1).

Rearing and Release of the Weevils

The weevils were collected indiscriminately from the infested fields, tunneled roots and they were brought to the Plant Sciences laboratory, Wolaita Sodo University and screened on the basis of their stage development. Then the adult weevils were allowed for mating and 5 days later they were transferred to pots with weevil-free sweet potato weevils. Seven days later, larvae of uniform stage of development was obtained. The activity was performed iteratively till the number of weevils became sufficient enough for release. About ten adult weevils were placed right at the center of the selected spot. The treatments were applied instantly after release of the weevils. Data collection had been carried out on the first, third, seventh, fourteenth and twenty first dates after the treatments. Data collection had been carried out on the first, third, seventh, fourteenth and twenty first dates after the treatments.

Data Collection

Data on root girth, root length, length of vines, mean number of damaged roots, number of emergence holes per tuber (damage severity) and number of tubers per emergence holes (incidence) had been collected, as recommended by Bamaiyi [12] and PPRSD [13]. Other data that had been collected include:

Extent of insect caused foliage damage (using a 1-5 damage score, where 1=0%, 2=1-25%, 3 = 26-50%, 4=51-75, 5=76-100%) [1]. Non-destructive damage scoring of infestation levels: - roots from each plot were separated into different categories depending on the percentage of the external surface showing *Cylas* spp damage. Five point score was used, where 1= 0%, 2=1-25%, 3 = 26-50%, 4=51-75, 5=76-100%). The mean root was calculated for each plot.

Percentage (marketable) infested roots (by number) (for roots with diameters >25mm), Percentage (marketable) infested roots (by weight) (for roots with diameters >25mm). All collected data were subjected to analysis of variance at p<0.05 using the SAS® statistical analysis program (release 9.2 for Windows) [14]. Data for pest abundance, damage level and percent yield loss were subjected to analysis of variance (ANOVA). Mean values of pest damage characteristics were determined at the three cultivars and separated using the Fisher's LSD test (p=0.05). Spearman's correlation coefficients were calculated between cultivar types and yield attributes.

Results

The influence of cultural practices on the extent of damage and yield parameters had been evaluated. These include number of emergence holes per root (damage severity) and number of root per emergence holes (incidence), Mean number of tunneled roots (MTR), Mean vine length (MVL), Mean Root Weight/m^2(MRW), and Extent of insect caused Foliage Damage(EFD).

Evaluation of Cultivar difference on Damage Severity, Incidence, vine tunneling, vine length, Root Weight and defoliation

The varietal resistance has a significant effect on the number of emergence holes per roots. Although the damage severity in the local variety was extremely high (8.5), there is no significant difference between the severity on *Temesgen*(5.5.) and *Awassa 83* (6). Local variety, on the contrary, had shown the highest damage severity implying that the improved varieties were more tolerant to weevil than local variety. Conversely, the variety *Temesgen* was the least damaged variety while the local variety had shown the highest number of emergence holes per roots (Table 1).

Table 1. The effect of varietal resistance on number of emergence holes per root (damage severity) and number of root per emergence holes (incidence), Mean number of tunneled roots (MTR), Mean vine length (MVL), Mean Root Weight/m^2(MRW), and Extent of insect caused Foliage Damage(EFD)

Variety	DS	DI	MTV	MVL	MRW	EFD
Awassa 83	6b	8.5a	22.34b	951.5a	2.75	15.67b
Temesgen	5.5b	4.54b	29.67a	789.8c	3.48	21a
Local Var.	8.5a	9.5a	30a	889b	3.56	16b
CD $_{0.05}$	1.33	5.41	3.32	21.63	1.8^{ns}	2.26

**Treatments with the same letters are not significantly different.*

There is significant difference (p<0.05) among the varieties in terms of weevil incidence. In line with this*Temesgen* showed the least number of roots with emergence holes (4.54) as compared to local variety (9.5) and *Awassa 83*(8.5). The variety *Temesgen,* therefore, should be encouraged for utilization by the farmers as far as effective weevil control is concerned. In harmony with the reports by Bamaiyi [11], varietal resistance has an inverse effect on the level of vine damage. *Awassa 83* had been with the least number of tunneled vines whilst local variety was with the highest number of vine tunneling. The variety *Temesgen* on which the least weevil damage severity was recorded, had shown the least vine length (789.8mm). *Awassa 83* had been with the longest vine length (951.5mm) whilst local variety was with the lowest vine length (889mm). There was a very significant difference among cultivars in insect caused foliage damage. And the variety *Awassa* 83 (with 15.67%) and local variety (with 16%) had shown least insect caused foliage damage. Whereas, *Temesgen*, with 21% insect caused foliage damage had been the most superior cultivar.

Influence of botanical plants on Damage Severity, Incidence, vine tunneling, vine length, Root Weight and Defoliation in different watering schemes

All treatments gave a comparatively similar weevil survival to the control (Malathion 50% EC) except *M. azadirachta* under irrigated condition. Plots treated with *Lantana camara* under both irrigated and non-irrigated conditions gave a comparatively inferior weevil survival, with 6.34 and 6, respectively. The highest weevil survival was recorded on plots treated with *M. azadirachta* (9 and 7, in non-irrigated and irrigated conditions, respectively)(Table 2). The botanical plants had inferior result as compared to commercial insecticides in reducing the number of larva. Especially, plots treated with Malathion under non-irrigated condition had shown the lowest larval count (4.67) though it was found at similar level of significance with irrigated condition. In other words, the mortality rate was very high in Malathion than any other botanical applied in the study.

Lanatana camara was observed to have a potential against sweet potato weevil by reducing the number of the level of weevil damage severity and incidence with 6.34 and 7, respectively, thus, under irrigated condition, it should be encouraged. Their interaction, furthermore, shows that there is slight interaction effect among the treatments. The noxious plants, if applied at irrigated condition, had shown to have the lower weevil damage severity when compared with the commercial insecticide taking the interaction of the chemical/noxious plant with irrigation against the ultimate weevil incidence.

Table 2. The effect of botanicals on number of emergence holes per root (damage severity) and number of root per emergence holes (incidence), Mean number of tunneled roots(MTR), Mean vine length(MVL), Mean Root Weight(MRW), and Extent of insect caused foliage damage(EFD)

Treatment	DS	DI	MTV	MVL	MRW	EFD
M. azadirachta + Irrigation	9a	9.34a	15a	126c	1443.34c	11a
M. azadirachta	7b	8.67ab	15a	116.34cd	1658.34ab	9a
L. camara + Irrigation	6.34b	7.00ab	12b	124.54cd	1469.67c	8.67ab
L. camara	6b	11.00a	13.34a	147b	1554bc	6.67bc
Malathion + Irrigation	5.67b	5.00ab	14a	211.34a	1741a	9.67a
Control (untreated)	6b	4.67bc	12.67a	151.67b	1905.67a	7.67bc
$CD_{0.05}$	1.33	5.41	2.67	21.63	180.13	2.26

**Treatments with the same letters are not significantly different.*

This, however, cancels out the results that have been obtained on vine tunneling on the same investigation. This may be due to the preference of the weevil on the roots than the vines. Furthermore, weevil damage severity in vines exceeds that of roots. The lowest count of vine damage (12) had been recorded on plots that had been treated with extracts of *L. camara* under irrigated conditions. Their interaction, furthermore, shows that there are no associations between the noxious plants applied at various irrigation schemes and vine tunneling by the weevil.

Plots treated with *M. azadirachta* under both irrigated and non-irrigated conditions had depicted the lowest vine length (124.54cm) in the same way as *L. camara* treated plots. Intermediate vine length (147cm) had been recorded on plots that had been treated with extracts of *L. camara* under irrigated conditions. This implies that the length of vines was not due to the effect of noxious plants but due to the effect of irrigation. Plots treated with Malathion had shown the highest vine length under irrigated and non irrigated conditions (with 211.34 and 151.67cm, respectively). None of the plots treated with noxious plants outweigh plots treated with Malathion in terms of root weight under irrigated and non-irrigated conditions. However, aqueous extracts of *M. azadirachta* L. at non irrigated condition had given a comparable result of root weight to commercial insecticide. Plots treated with *M. azedrachta* had shown greater defoliation both under irrigated and non-irrigated conditions, with 11 and 9 respectively. The lowest leaf defoliation, however, recorded from the untreated plots. On the contrary, plots treated with Malathion 50% EC (9.67) under irrigated condition had shown medium leaf defoliation (9.67). The lowest defoliation was observed from plots treated with *L. camara* in both conditions (8.67 and 6.67). Besides, untreated plot also had the least defoliation (7.67).

Influence of Cultivar Differences on Marketable Yield by Number and Weight, Exposure, Mean Root Girth, mean Root Girth internal Damage

There a statistical difference in the mean percent of marketable yield by number among the varieties under study. The highest mean percent of marketable yield by number and weight was observed from the variety *Temesgen* (with 22% and 22.33%). The variety *Awassa* 83, with 42.67% and 45.17% of mean marketable yield by number and weight, was the second most superior cultivar. However, the local variety had shown the lowest percentages of marketable yield by number and weight with 86.67 and 93.33 percent.

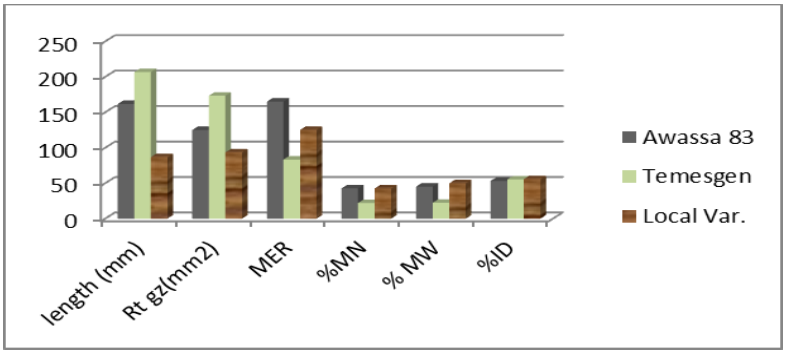

Fig 1. Marketable yield by number (%MN) and weight (%MW), Mean Exposed roots (MER), mean root girth (Rtgz), and internal damage (%ID) as influenced by cultivar differences

The longest and thickest root was recorded from the variety Temesgen (with 206.67 and 173.33mm, respectively) and Awassa 83, with 161.67 and 125 mm of mean root length and girth, was the second most superior cultivar. However, the local variety had shown the lowest mean root length and girth of 86.67 and 93.33 percent. The highest mean number of exposed root was observed from the variety Awassa83 (with 165). Local variety, with 125 of mean number of exposed roots, was the second most inferior cultivar. However, the *Temesgen* was observed as the least variety with the mean number of root exposure of 83.33(Fig 1).

Influence of botanicals on Marketable Yield by Number and Weight, Extent of leaf Foliage, Mean Root Girth, mean Root Girth internal Damage in different irrigation schemes

Plots treated with *M. azadirachta* (with 41.33 and 42%) and *L. camara* (with 44.67 and 43%) under irrigated condition gave the highest percent of mean marketable yield by number and weight, respectively. There is a considerable difference among the treatments in terms of root size and length. The highest root length and size was observed in plots treated with *M. azendrachta* (with 180 mm) and malathion 50% EC(with 180mm) under irrigated condition(Fig.2.).

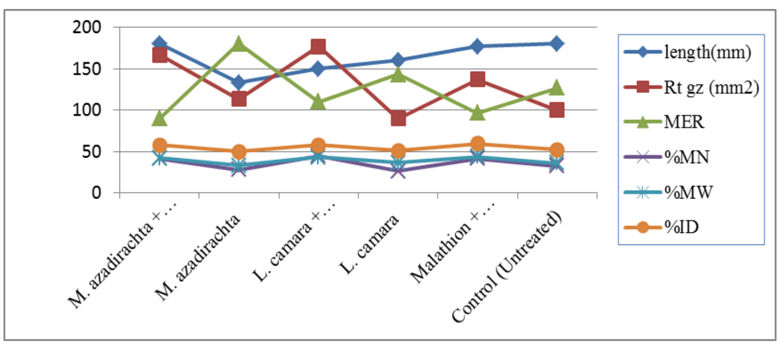

Fig 2. Influence of botanicals on marketable yield by number (%MN) and weight (%MW), Mean Exposed roots (MER), mean root girth (Rtgz), and internal damage (%ID) in different irrigation schemes

There was a general trend in reduction of number of damaged roots under irrigated condition. The number of tunneled roots was higher in plots treated with both *L.camara* and *M. azadirachta* under irrigated conditions. Furthermore, plots treated with Malathion 50% EC under irrigated condition were found to be superior to that of untreated check. Regression analysis indicated that the length and size of the roots are directly related to the extent of damage and indirectly related to mean percent of yield by number (with r= -0.97) and weight(r= -0.91). This fortify that the deep rooted varieties to be less prone to weevil damage than the shallow rooted ones.

Discussion

This study corroborated that *Melia azadirachta* is the preeminent botanical that needed to be applied in irrigated condition. Neem-based pesticides are easy to prepare, cheap and highly effective, providing a long term protection [15] to plants against pest and constitute an important source of pesticide [15] for economically poor third world country farmers. This could be attributed to the residual effect of azadirachtin and may have been hastened by climatic factors [16]. *Melia azadirachta* gave the highest seed weight (1658.34gm/plant), but the lowest vine length and mean size with 116cm and 9cm, respectively, this corroborates the findings that neem products [17] performed equally or sometimes better than some synthetics. It appears that neem seed oil could be a potential source of natural and low-cost insecticide to control Sweet potato pests. Earlier study by Isman*et al.* [18] concluded that the bioactivity of neem was dependent on its azadirachtin content. Furthermore, the high incidence of the weevil at various stages of development on the control plot indicated the high susceptibility of the Local variety to weevil attack as reported by Anioke and Ogbalu [19]. However, the application of malathion 50% EC treatments had a significant reduction in the sweetpotato weevil infestation and damage of roots. This suggests that the chemicals applied are more effective in a condition where by water is more available and mobility and efficacy of commercial insecticides are more in irrigated condition than dry soil environment. Nevertheless, oils have been reported to cause the death of developing embryo through asphyxiation [20]. However, the significantly lower number of the immature stages, despite the higher adults could be attributed to exit of the weevil following it emergence from the roots.

It was also revealed that there is a strong association between weevil damage and soil condition. The more dry and clayey the soil is the higher the weevil infestation. This corresponds to the reports made by Smit and Huis [21]. Furthermore, the positive responses of root yield in plots treated with irrigation+ chemicals/noxious plants implied that the irrigation, not the noxious plants, affected root size strengthening the previous reports [12]. Ehnsianya *et al*. [22] reported that the reduction in yield may be attributed to root dehydration caused by increased weevil tunneling, soil cracking, higher temperature and lower rainfall. The result also corroborated increased weevils infestations and remarkably injurious during the drier growing season. On the whole, both conditions are vital means of managing sweet potato weevil at larval stage. The level of weevil attack, infestation level, survival and loss were varied typically on the basis of variety. The finding supports the reports of Katwale *et al.* [23] who reported that variation on susceptibility to weevil attack occurred among cultivars. The Improved varieties, particularly the variety *Temesgen* had shown least attack although it was in the slightest preference of the farmers because of its low yield implying that the farmers appreciated the yield more than quality.

The level of tunneling varies depending upon variety. The integrated use of varietal resistance and noxious plants in wet soil environment is promising as far as effective sweet potato weevil management is concerned. And varietal resistance is the consummate elucidation of a sustained sweet potato weevil control at pre and post harvest levels as stated by Stathers*et al.* [1].

The size of the local variety is superior to the improved ones. Despite its extra size, the majorities of the harvested roots in the local variety were not considered as recommended by Kays and Kays [24] and were excluded from measurement as they didn't fulfill the pre-specified size, defect-free quality and conditions. The variety *Temesgen* had, thus, shown superior root size. Moreover, the spearman's correlation coefficient proved to have no significant impact implying that there are no associations between the noxious plants applied at various irrigation schemes on vine length.

Conclusion

The study revealed that the integration of noxious plants and irrigation, applied singly or in combination was not phytotoxic to the crop and it significantly lowered C. *puncticollis* infestation and damage of Sweet potato roots in delayed production and thus, provided adequate protection of vines and roots. Under main or rain-fed Sweet potato cropping, plant extracts should be used to minimize damage by C. *puncticollis* in field.

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