Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.7, No.8, 2017

Evaluation of Integrated Management Practices of Sweet Potato Weevil (Cylas Puncticollis (Boheman) (Coleoptera: Brentidae) in Bako, Western Ethiopia

Abraham Negera* Feyera Takele Tilahun Wondimu
Bakko Agricultural Research Center: P.O box 03, Bako

Abstract
The study was targeted to evaluate integrated sweet potato weevil (Cylas puncticollis) management practices for quality and high root yield production of sweet potato. It was conducted at Bako Agricultural Research Centre during main season of 2013 and 2014. The treatments were arranged in randomized complete block design in factorial arrangement with three replications. Different ridge height and harvesting date of sweet potato was significantly ($p \leq 0.05$) affected Yield of sweet potato. Analyses of variance indicate that the highest marketable root (41.888 tons/ha) was obtained from 30cm ridge height with five month of harvesting date and the lowest marketable root weight (22.125tons/ha) was recorded from 50cm ridge height with six month harvesting date of sweet potato. Application of insecticide was not significantly ($p \leq 0.05$) affected the yield of sweet potato. Thus 30cm ridge height and 5month harvesting date after planting of sweet potato was recommended as sweet potato weevil management options to increase its marketable yield and quality of tuber at the area.
Keywords: Sweet Potato Weevil, ridge height, harvesting time

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is a perennial herb (Bartolini, 1985) but behaves as an annual when cultivated. Among the most important root and tuber crops, Sweet potato (*Ipomea batatus* L.) is one of the major traditional food crops of Ethiopia (Endale et al., 1994). It is an attractive crop among farmers due to its high productivity, universal uses, high caloric content and good taste. It is a known crop gifted with high potential to tolerant adverse environmental conditions such as drought, low soil fertility, high rainfall and it requires very little labor and care compared to other crops (Lebot, 2009). Apart from its high caloric content, sweet potato is also one of the cheapest potential sources of vitamin A to alleviate problem of night blindness and infant mortality from which millions of children from sub-Saharan Africa are facing. With all its desirable traits, Sweet potato greatly contributes to food security and farmers' income (Terefe, 1994). Based on CSA report of 2015/16 the national average yield of sweet potato in Ethiopia was 33 tons per hectare. Ridge height and planting angle determined the final root yield where the 40 cm ridges had the highest yield (Parwada et. al, 2011).

The African sweet potato weevil (*Cylas puncticollis*) is one of the most important pests of sweet potato in tropical Africa, notably Uganda, Rwanda, Kenya and Cameroon. *Cylas brunneus* is known from West and Central Africa and some countries in East Africa (Rwanda, Burundi and Kenya). These two species are found together attacking sweet potatoes in East and West Africa (Hill, 1983). *Cylas formicarius* is a destructive pest of sweet potato throughout most of the tropical and subtropical regions and occurs in several African countries. Adult weevils feed on leaves, the underground storage roots and the vines of sweet potatoes. They prefer to feed on storage roots, but at the beginning of the growing season, when the plants have not yet produced storage roots, the adult weevils live on the stem and leaves. They lay eggs on vines and leaves, and the grubs will feed in the stem or the leaf and pupate inside the vines. As the plant gets older and starts to form storage roots, the weevils search for exposed roots. Since they cannot dig, they reach the tubers through cracks in the soil.

Feeding and egg-laying punctures (numerous small holes) lower the quality of the root and can reduce the market price. The grubs are more damaging, feeding, boring and making tunnels into the stems and roots. Damage to the stems may cause serious mortality to seedlings. Allard et al. (1991) reported on serious weevil attacks on sweet potato nurseries in Ethiopia.

Increase in time of harvest extends the growth of the plant into drier periods of the year. Dryness of soil and bulking of roots causes cracking of soil, which exposes the roots and allows weevil asses to the roots for oviposition. Also temperature and rainfall to increase soil moisture which makes assess to root for oviposition by adult female *C. puncticollis* difficult since the weevil cannot dig (Sherman and Tamashiro, 1954). Harvest time is also critical for infestation and damage as piecemeal harvesting to 5 and 6 months after planting. There was a positive correlation between root yield and weevil density, percentage root infestation and damage.

Agronomic management of Sweet potato with a view to reducing the damage caused by weevils depends on an understanding of the fundamental factors that influence the incidence and damage by *C. puncticollis* in the field. The integration of elite sweet potato varieties, tillage method and sequential harvesting has the potentials to influence infestation, development and damage caused by this weevil under natural infestation pressure. This study will examines the variation exists within some of integration of tillage methods, chemicals and sequential harvest time to effectively manage field infestation and subsequent damage to sweet potato root by *C. puncticollis.* To evaluate integrated sweet potato weevil management practices for quality and high root yield production of sweet potato.

MATERIALS AND METHODS

The experiment was conducted at Bako Agricultural Research Centre during main season of 2013 and 2014. Sweet potato cuttings of variety Tola were planted at 100cm x 30cm between rows and plants respectively on 4x3m plots size. All agronomic packages were applied during production periods. Three harvesting time (at 4, 5, and 6 months after planting), three ridge height (30cm, 40cm, and 50cm) and insecticide (treated with Diazinon and untreated) treatments were arranged in randomized complete block design in factorial arrangement with three replications. Insecticide chemical (Diazinon) was sprayed two times on treated plots every 20 days from the occurrence of the sweet potato weevil. Weevil infestation assessment on tuber yield was carried out at each harvesting time and yield data was recorded from central rows of the trials. The harvested tuber yield was categorized as marketable and un-marketable based on tuber size and weevil infection. All collected data were analyzed using SAS computer software.

Yield loss in different treatments will be calculated as percent yield loss by employing the formula (Robert and James, 1991)

$$\text{Relative yield loss (\%)} = \frac{100 \times (\text{YCP} - \text{YDP})}{\text{YCP}}$$

Where, YCP: Yield in controlled plot; YDP: Yield in non-controlled plots of the treatment.

RESULT AND DISCUSSION

Sweet Potato Weevil Infestation

Sweet potato infestation was significantly different (0.05 probability level) between the two years assessment. Therefore, the two years data of the assessments were analyzed separately. Interaction of ridge height, harvesting time and insecticide application significantly differed in weevil attack in 2013 and 2014 main cropping season. Regardless of ridge height and insecticide spray harvesting time significantly, affect sweet potato tuber attack. Tuber yield attacked by sweet potato weevil was significantly lower at 4th and 5th month harvesting time. However, sweet potato weevil attacked was increased with increasing harvesting time in both years. Sweet potato tubers harvested at 4th and 5th months showed free of sweet potato weevil in 2013. Tuber harvested at fourth month showed free of sweet potato weevil in 2014 and also reduced on tuber harvested at fifth month. Sweet potato attack was highest (5333.34 kg/ha) at harvesting time of six months and 50 cm ridge height in 2013 and (1250 kg/ha) in 2014(Table 1).

Marketable Tuber Yield

Significantly different marketable tuber yield was observed 2013 due to the interaction of management options (Table 1). Regardless of insecticide application, days to harvesting and ridge height significantly affect sweet potato tuber yield. On yields harvested from plots planted at 30 cm ridge height and harvested at five months from planting, regardless, of insecticide spray showed higher marketable tuber yield in both years. Generally, analysis of variance showed that Diazinon application to control sweet potato weevil was not significant to non-sprayed plots.

Interaction effect of main effects (harvesting time, ridge height and insecticide application) significantly affected unmarketable tuber yield. As tuber yield harvesting time increased from four month to six month unmarketable yield increased to 4444.45 kg/ha and 21583.33 kg/ha in 2013 and 2014 respectively (Table 1).

Unmarketable Tuber Yield

Weight of unmarketable tuber yield was significantly differed in the interaction of sweet potato weevil management options (ridge height, harvesting date and insecticide spray) in both 2013 and 2014 cropping season. Significantly highest (6.4 ton ha^{1s}) unmarketable tuber yield was observed on plots planted on 30 cm ridge, non-sprayed with insecticide and harvested at six month in 2013 (Table 1). Regardless of ridge height and insecticide spray, six month of harvesting time showed high unmarketable tuber yield. This may be as harvesting time increase, tuber infection by sweet potato weevil increase. Also, in 2014 unmarketable tuber yield were higher on plots harvested at six months from plants (Table 1).

Table 1: Interaction effect of ridge height, harvesting and insecticide application on weevil attack, marketable and unmarketable tuber yield (kg ha^{-1}) at Bako in 2013 and 2014 main cropping season.

			2013			2014		
Ridge height	Harvesting date	Insecticide	Weevil attack	Marketable yield	Unmarketable yield	Weevil attack	Marketable yield	Unmarketable yield
Thirty	Four	Diazinon	0.00 f	26667 d-f	1000.00 dc	0.00 i	25833.39 e	555.56 i
Thirty	Four	Non	0.00 f	27500 d-f	3333.33 bc	0.00 i	28166.67 e	333.33 i
Thirty	Five	Diazinon	0.00 f	40722.00 a	833.34 e	222.23 f	44444.44 a	2055.56 fg
Thirty	Five	Non	0.00 f	38611.00 a	944.44 de	144.45 g	43777.78 a	1194.45 g-i
Thirty	Six	Diazinon	722.23 e	24000 ef	2666.67 b-d	638.89 c	38055.55 a-c	6388.89 d
Thirty	Six	Non	3166.67 b	38167 ab	6388.89 a	483.33 d	27750.00 e	4641.67 e
Fourty	Four	Diazinon	0.00 f	26111 d-f	1750.00 c-d	0.00 i	27083.34 e	2072.33 fg
Fourty	Four	Non	0.00 f	28333 c-f	1111.11 de	0.00 i	29833.22 de	2555.56 f
Fourty	Five	Diazinon	0.00 f	37167 ab	944.44 de	0.00 i	40833.33 ab	833.33 hi
Fourty	Five	Non	0.00 f	34583 a-c	416.67 e	142.23 g	35833.33 b-d	3666.67 e
Fourty	Six	Diazinon	1666.67 d	31389 b-d	3555.56 b	244.44 ef	39444.44 ab	6944.45 d
Fourty	Six	Non	1777.78 d	29611 c-e	3500.00 bc	277.78 e	31388.89 c-e	8516.67 c
Fifty	Four	Diazinon	0.00 f	27500 d-f	722.22 e	0.00 i	27666.67 e	1500.00 gh
Fifty	Four	Non	0.00 f	21667 f	1166.67 de	0.00 i	28333.37 e	555.56 hi
Fifty	Five	Diazinon	0.00 f	35278 a-c	1055.56 de	11.11 i	42666.67 ab	333.33 i
fifty	Five	Non	0.00 f	39167 a	666.67 e	77.78 h	39500.00 ab	1055.56 hi
Fifty	Six	Diazinon	2777.78 c	24667 d-f	4444.45 b	1033.34 b	16750.00 f	21583.33 a
Fifty	Six	Non	5333.34 a	29583 c-e	3388.89 bc	1250.00 a	17500.00 f	20416.67 b
Mean			858.02	31151.24	2104.94	269.75	32492.28	4733.49
CV			18.73	13.62	50.09	8.77	13.90	12.65

Means followed by the same or no letter within the column are not significantly different from each other at 0.05 probability level, DMRT test

Table 2: Effect of management options on relative yield loss (%) of sweet potato at Bako in (2014 and 2015) main cropping season

Ridge height	Harvesting date	Insecticide	Mean yield (ton)	Relative yield loss %)
Thirty	Four	Diazinon	26.25	38.4
Thirty	Four	Non	27.83	34.6
Thirty	Five	Diazinon	42.58	0.0
Thirty	Five	Non	41.19	3.3
Thirty	Six	Diazinon	31.03	27.1
Thirty	Six	Non	32.96	22.6
Fourty	Four	Diazinon	26.60	37.5
Fourty	Four	Non	29.08	31.7
Fourty	Five	Diazinon	39.00	8.4
Fourty	Five	Non	35.21	17.3
Fourty	Six	Diazinon	35.42	16.8
Fourty	Six	Non	30.50	28.4
Fifty	Four	Diazinon	27.58	35.2
Fifty	Four	Non	25.00	41.3
Fifty	Five	Diazinon	38.97	8.5
Fifty	Five	Non	39.33	7.6
Fifty	Six	Diazinon	20.71	51.4
fifty	Six	Non	23.54	44.7

RH, ridge height, and DH is harvesting date

Relative Yield Loss

Relative tuber yield losses of the treatments were calculated from their respective treatment offering maximum protection and maximum yield. Maximum (51.4 and 44.7%) relative tuber yield losses were calculated from plots harvested at six months from planting and planted on 50 cm ridge height regardless of insecticide application. However, plots planted on 30 cm ridge height and harvested at five months from planting regardless of insecticide application estimated minimum relative tuber yield loss (Table 2). Similar to this study crop loss from weevil damage range from 5 to 80%, with weevil damage increasing the longer the crop remains un-harvested. Also in experiment station trials, losses of 3-80% were recorded in Indonesia, depending on location and season (Bahagiawati, 1989) and damage from weevils was highest during the dry season (Braun and van de Fliert, 1999)

Table 3: Simple correlation coefficient among the variables studied at Bako, Western Ethiopia

Parameters	Weevil attack (kg ha^{-1})	Marketable yield (kg ha^{-1})	Unmarketable yield (kg ha^{-1})	Yield loss (kg ha^{-1})
Weevil attack	1	-0.14^{ns}	0.28**	0.48**
Marketable yield		1	-0.38**	-0.48**
Unmarketable yield			1	0.96**
Yield loss				1

^{ns} non-significant, * significant and ** highly significant

Table 4: Cost benefit analysis of sweet potato production as influenced by weevil management options

Ridge height	Harvesting date (month)	Insecticide	Average Marketable yield (kg)	Gross Return (Birr ha^{-1})	Cost that vary	Marginal net benefit	MRR
Thirty	Four	Diazinon	26250.20	78750.59	2650.00	76100.59	-
Thirty	Four	Non	27833.34	83500.01	1500.00	82000.01	0.00
Thirty	Five	Diazinon	42583.22	127749.66	4150.00	123599.66	15.70
Thirty	Five	Non	41194.39	123583.17	3000.00	120583.17	25.72
Thirty	Six	Diazinon	31027.78	93083.33	5650.00	87433.33	-
Thirty	Six	Non	32958.50	98875.50	4500.00	94375.50	-
Fourty	Four	Diazinon	26597.17	79791.51	4150.00	75641.51	-
Fourty	Four	Non	29083.11	87249.33	3000.00	84249.33	1.50
Fourty	Five	Diazinon	39000.17	117000.50	5650.00	111350.50	-
Fourty	Five	Non	35208.17	105624.50	4500.00	101124.50	-
Fourty	Six	Diazinon	35416.72	106250.16	7150.00	99100.16	-
Fourty	Six	Non	30499.95	91499.84	6000.00	85499.84	-
Fifty	Four	Diazinon	27583.34	82750.01	6150.00	76600.01	-
Fifty	Four	Non	25000.19	75000.56	5000.00	70000.56	-
Fifty	Five	Diazinon	38972.34	116917.01	7650.00	109267.01	-
fifty	Five	Non	39333.50	118000.50	6500.00	111500.50	-
Fifty	Six	Diazinon	20708.50	62125.50	9150.00	52975.50	-
Fifty	Six	Non	23541.50	70624.50	8000.00	62624.50	-

MRR: marginal rate of return and the (-) in MRR indicates the dominated treatments with dominance analysis

Correlation analysis of the variable showed significant and positive correlations between weevil attacked tubers weight and unmarketable tuber yield (r = 0.28**), percent yield loss (r = 0.48**). Similarly, unmarketable tuber yield was positively and significantly correlated with yield loss (r = 0.96**) (Table 3). However, marketable tuber yield was negatively and highly significantly correlated with unmarketable tuber yield (r = -0.38) and yield loss (r = -0.48).

Cost-Benefit Analysis in Sweet Potato Weevil Management Options

Partial budget analysis of sweet potato weevil management options indicated that the highest (ETB 123599.66 ha^{-1}) marginal benefit was obtained from plots sprayed with Diazinon, planted on 30cm ridge and harvested five months after planting followed by sweet potato planted on thirty cm ridge height and harvested at five months after planting without insecticide application (Table 4). In addition, the marginal rates of return were calculated for the significant treatments under dominant analysis for comparison of the treatment cost/benefit of the treatments (Table 4).

Sweet potato planted on ridge height of thirty centimeter and harvested five months from planting without insecticide application provided higher (ETB 25.72) marginal rate of return than the other sweet potato weevil management option tested in this experiment.

CONCLUSION AND RECOMMENDATION

The trial was conducted in the BARC for two years. The study was initiated by the objective to determine optimum root harvesting time and ridge height as well as economically optimum insecticide application scheme for harvesting weevil free root yield of sweet potato. The experiment revealed that 30cm ridge height with 5 month harvesting date was effective to manage sweet potato weevil and to maximize marketable yield of sweet potato. The economic analysis of sweet potato weevil management options indicated that the highest marginal rate of return was obtained from the plots sweet potato was planted on 30 cm ridge height and harvested five months from planting without any insecticide application. Therefore, producers were more benefited than the others option to obtained high yields by minimizing weevil infestation. Thus 30cm ridge height and 5month of harvesting date of sweet potato was recommended as sweet potato weevil management options to increase its marketable yield.

ACKNOWLEDGMENT
We would like to acknowledge Oromia Agricultural Research Institute for funding this experiment and Bako Agricultural Research Center for facilitating finance administration. Also our appreciation goes to all Horticultural team members of Bako Agricultural Research centers for their follow up the activity and data collection.

REFERENCES
Allard G.B, Cock M.J.W and Rangi D.K. (1991). Integrated control of arthropod pests of root crops, Final Report. Nairobi, Kenya: CAB International.

Bahagiawati, A. H. (1989). Bionomics and Control of the Sweet potato Weevil, *Cylas formicarius* in Indonesia, Bogor Research Institute for food crops, Bogor, Indonesia

Bartolini, U. P. (1985). Sweet potato: Its classification and description. Philippine root crop information service, *Root Crop Digest Vol*. 1, 4pp.

Braun, A. R. and E. van de Fliert, E. van de. (1999). Evaluation of the impact of Sweet potato weevil (*Cylas formicarius*) and of the effectiveness Of *Cylas* sex pheromone traps at the farm level in Indonesia, International Journal of Pest Management, vol. 45, no.2, pp.101–110,

CSA (Central Statistical Agency). 2015. *Area and production of major crops*. Volume I, Addis Ababa, Ethiopia.

Parwada, C. T., Gadzirayi A. B. and Sithole. (2011). Effect of ridge height and planting orientation on *Ipomea batatas* (sweet potato) production. Journal of Agricultural Biotechnology and Sustainable Development Vol. 3(4) pp. 72-76, April 2011

Endale, T., Terefe, B., Mukgeta, D., Geleta, L. (1994). Improvement studies on Enset and Sweet potato. In: proceedings of the second national Horticultural workshop in Ethiopia, 1-3Dec.1992. Addis Ababa, Ethiopia.

Hill, D. (1983). Agricultural insect pests of the tropics and their control. 2nd edition. Cambridge University Press. ISBN: 0-521-24638-5.

Lebot, V. (2009). Tropical root and tuber crops cassava, sweet potato, yams and aroids, CABI, Oxfordshire, UK, pp. 91-274.

Terefe, B., Geleta, L. (1994). Agronomic Studies on Sweet potato. In: proceedings of the second national Horticultural workshop in Ethiopia, 1-3 Dec.1992. Addis Ababa, Ethiopia.

Sherman, M. and Tamashiro, M. (1954). The sweet potato weevil in Hawaii: their biology and Control. *Hawaii Agric Exp Stn. Bull.* 23: 1-36