Agricultural and Biological Sciences Journal
Vol. 6, No. 4, 2020, pp. 176-181
http://www.aiscience.org/journal/absj
ISSN: 2381-7178 (Print); ISSN: 2381-7186 (Online)

Maize Weevil, *Sitophilus zeamais* (Motsch.) (Coleoptera: Curculionidae), Infestation in Stored Maize and Control Practices in Ethiopia

Yilma Nibret[1], Oljira Kenea[1, *], Tifsehit Solomon[1], Pichiah Gomathinayagam[2]

[1]Department of Biology, College of Natural and Computational Sciences, Wollega University, Nekemte, Ethiopia
[2]Department of Plant Science, College of Agriculture, Wollega University, Shambu, Ethiopia

Abstract

Maize (*Zea mays* L.) is one of the most important food crops produced mainly for subsistence and maintaining household food security by smallholder farmers in Ethiopia. Maize weevil, *Sitophilus zeamais* is the prime pest of stored maize and the main cause of postharvest loss in the country. The aim of this study was to assess the infestation rate, weight loss, storage management and control practices of the maize weevil by small holder farmers in Adet Zuria, Ethiopia. In this study 200 quintal sample points from 20 households were taken at random for measuring the infestation rate of the maize weevil. One way ANOVA was used to determine the weight loss of the maize taken at three different portions in bag store; bottom, middle and top portions. A household survey was conducted in May 2019 in a random sample of 360 maize farmers to assess postharvest storage management and maize weevil control practices in the study setting. The infestation rate of maize weevil from 200 quintal sample bag store was 79.5%. There was statistically different weight loss of the maize grain along the bag store. High weight loss was observed at the middle of the bag store compared to the bottom and the top. Most of the farmers (90.3%) store their maize grain in traditional storage structures particularly in bags and gota. The major control and management practice of the local people against the maize weevil in the study area was chemical pesticides. In conclusion, the infestation rate of the maize weevil in stored maize in Adet zuria Kebele was very high and the farmers store their maize in traditional storage structures and rely on chemical insecticides for protection against the weevil. Therefore integrated maize weevil management actions should be undertaken that include improvement of storage structures and ecofriendly management of the maize weevil.

Keywords

Adet Zuria, Bag Store, Maize Weevil, Pest Management, Storage Structure

Received: October 13, 2020 / Accepted: October 28, 2020 / Published online: November 23, 2020

1. Introduction

Maize (*Zea mays* L.) is a major staple crop for many smallholder farmers over the world. It holds strong promise against poverty and global food crisis. In sub-Saharan Africa (SSA), about 50% of the population depends on maize for food [1]. It plays an important role in the livelihood of smallholder farmers contributing 34-36% daily calorific intake in East Africa and 10% in West Africa [2]. In Ethiopia maize is one of the main stable food crops and one of the main sources of calories [3, 4]. The crop has been selected as one of the national commodity crops to satisfy the food self-sufficiency program of the country to feed the alarmingly increasing population [4]. It is commonly stored for

* Corresponding author
E-mail address: oknoodz@gmail.com (O. Kenea)

consumption until the next harvest, as seed for planting in the next season and for selling when prices become favorable by the small holder farmers [5].

The maize weevil, *Sitophilus zeamais* is the prime pest of stored maize and the main cause of postharvest loss in Ethiopia. It is estimated that, the maize weevil caused about 20% storage losses and 25% price reduction for the damaged grains for maize in the country [6]. The adult female weevil attacks whole grains whereas the larva feeds and develops within the grains [7]. Damage to grain caused by this weevil includes reduction in nutritional value, germination, weight and commercial value [8]. Infestation by this primary colonizer may facilitate the establishment of secondary colonizers such as mite pests and stored product pathogens [9]. The favorable tropical climatic conditions and poor storage systems in the country often favor growth and development of the weevil, resulting in considerable losses [5]. In some instances, farmers are forced to sell their maize grains off cheaply soon after harvesting due to anticipated losses in storage and later buy food at higher prices. For many small holder farmers in Ethiopia and elsewhere in SSA, these losses threaten household food security and undermine market returns [4].

Considering the prime concern and action of achieving food security and food safety in Ethiopia, there is need for simple and effective pest management approaches for smallholder farmers who form the bulk of the maize grain producers in the country. For that, a number of approaches ranging from cultural to use of pesticides have been practiced for management of post-harvest maize pests. In spite of the ravages caused by maize storage pests, there exists very little information on the farmers' maize weevil management practices in Adet Zuria Kebele in north western Ethiopia. The current survey was conducted to assess the infestation rate, weight loss, and storage management and control practices of the maize weevil by small holder farmers in Adet Zuria, Ethiopia. This survey contributes to identify potential points for intervention in the development of integrated pest management strategies for storage pests of maize that are appropriate to the needs and circumstances of smallholder farmers in western Gojjam in particular and for rural Ethiopia in general.

2. Materials and Methods

2.1. The Study Area

The study was conducted in Adet Zuria kebele (AZK) a rural village (sub-district) in West Gojjam Zone of the Amhara National Regional State, in north western Ethiopia. Adet is found 42 Kms south of Bahir Dar, the capital city of the regional state, and 445 kms northwest of the Ethiopian capital Addis Ababa. It is geographically located at $11^{0}27'$N latitude and $37^{0}48'$E longitude at an elevation of 2238 meters above sea level. The total farming population of AZK was 1807 that comprised 1356 male farmers and 451 female farmers during the study period. The maize production per year at the study setting was 685,289 quintals. The most important economic activity in the area is mixed agriculture and small scale trade at the town level. Local rural residents primarily depend on farming and livestock rearing for their subsistence. Most of the population lives by farming activities in traditional type houses constructed of mud and wood with corrugated iron roofs and few in houses covered with straw roofs. The study site was selected based on maize production and maize weevil infestation information.

2.2. The Study Design and Sample Size Determination

Community-based house to house cross-sectional descriptive survey was carried out in May 2019 in AZK. The study populations were all maize farming households in AZK. The sources of data were small holder maize farming households in the kebele. For determination of infestation rate and grain loss, 15% of the total maize farmers of the study area were considered. The sample households were selected by systematic random sampling in which every 20^{th} household head was addressed. The sample size to assess postharvest storage management and maize weevil control practices by the small holder farmers was determined by Yamane's formula at 95% confidence level.

$$n=\frac{N}{1+N(e^{2})}$$

where N is the population size and e is the level of precision.

N=1807 study population

e=0.05

$$n=\frac{1807}{1+1807*(e^{2})}$$

n=327.5

To minimize errors from the likelihood of noncompliance, 10% of the sample size, which was counted to be 32 samples then added to the normal sample 328. Therefore, the total sample comes 360.

2.3. Inspection of Maize Infestation and Measuring Grain Loss by Weevil

The inspection of maize storage structures for the weevil infestation was carried out by visual observation. For maize weevil infestation rate determination, stored maize was inspected for the occurrence and signs of occurrence of maize weevil in 10 randomly selected maize sacks (bags) per household. That is 10 bags were randomly selected from the total bags per house for observation and sampling. Oviposition and emergence holes by the maize weevil were used as signs of infestation by the weevil. In this study the infestation rate was estimated only for the bag maize store, since the most frequently used storage structures were bag storage. More than 55% of the farmers used bag storage structure to store their maize.

However weight loss caused by the maize weevil was estimated from samples of grain collected from the farmers' store bags by using 50cm sample spear. The sample spear was used to collect 500gram samples from maize grain stored in bags and that takes 300 seeds. The samples were collected from different depth of the store particularly from the top, middle and bottom of the randomly selected store bags.

2.4. Survey of Storage Pest Management Practices

A household survey was conducted in May 2019 in a random sample of 360 maize farmers. To be eligible to participate in the study, the respondent had to be a household head above 18 years of age who was a primary decision-maker on household maize storage and management practices. A pretested semi-structured questionnaire was used to collect data from the respondents. The questionnaire was designed in English and translated into Amharic, which is understood by all of the farmers. The data collected consists of respondents' demographic information, maize production rate and the respondents' practices on maize postharvest handling and storage.

2.5. Data Analysis

Data analysis was done by using statistical software, SPSS version 20. The infestation rate of the maize weevil was the percentage of all possible samples in which the weevil occurred. It was calculated by using the following equation.

$$\text{Infestation rate} = \frac{(NSWP)}{(TNS)} x100$$

Where:

NSWP = number of store structure weevil positive

TNS = Total number of store structure.

To compute % weight loss, the pest damaged and undamaged grain from the sample was first counted and then weighed using count and weigh method. The % weight loss was then calculated using the following equation based on Gewinner *et al* [10].

$$\text{Weight loss \%} = \frac{(NdxWu) - (WdxNu)}{(Nd + Nu)XWu} x100$$

Where:

Nd = Number of damaged grains in the sample

Nu = Number of undamaged grains in the sample

Wd = Weight of damaged grains in sample

Wu = Weight of undamaged grains in the sample

One way analysis of Variance (ANOVA) was used to test whether there is statistical difference in the maize weight loss taken at different position. After statistical differences were observed in ANOVA, pairwise comparison was applied to identify which pair of the maize loss is statistically different from the other. Statistical differences were considered at $P < 0.05$.

3. Results

3.1. Infestation Rate of Maize Weevil

The occurrence and abundance of the maize weevil in Adet Zuria Kebele in a bag storage structure was shown in Table 1. As shown in the table, the infestation rate of the weevil in a total of 200 quintals of maize randomly observed in 20 households was 79.5%.

Table 1. Infestation rate of the Maize weevil, *Sitophilus zeamais* on maize sample taken from stored maize in Adet Zuria in 2019.

House No.	No. of infested bag store	House No.	No. of infested bag store
1	8	11	9
2	6	12	10
3	9	13	8
4	8	14	7
5	7	15	10
6	10	16	8
7	9	17	6
8	7	18	7
9	8	19	8
10	6	20	8
Total	78	Total	81

Infestation rate = 78 + 81 X 100/200 = 79.5%.

3.2. Weight Loss of Stored Maize Caused by the Weevil Infestation

The weight loss of stored maize due to maize weevil infestation ranged from 1.46% in the bottom portion to 2.95% in the middle portion of the bag store (Table 2). The mean weight loss at the top, middle and bottom of the bag store was 2.83, 7.96 and 6.08, respectively.

Table 2. The mean weight loss of maize at different portions of the bag store in Adet Zuria Kebele in 2019.

Bag portion	Range	Minimum	Maximum	Mean		St. deviation	Variance
				Stat.	Std. error		
Top	1.92	1.67	3.59	2.83	0.15151	0.52483	0.275
Middle	2.95	6.52	9.47	7.96	0.25606	0.88701	0.787
Bottom	1.46	5.20	6.66	6.08	0.11508	0.39866	0.159

The mean weight loss of maize at the top, middle and bottom portions of the bag store was statistically different (F = 198.486, df = 35, $p < 0.05$). The mean weight loss of maize at the middle of the bag store was significantly higher as compared to either the top or bottom portions of the bags (Table 3).

Table 3. Pair-wise comparison of weighted maize loss taken at the top, middle and bottom portions of the bag store.

(I) grouping factor	(J) grouping factor	Mean Difference (I-J)	Std. Error	Sig.	95% confidence interval	
					Lower Bound	Upper Bound
Top	Middle	-5.12917*	0.26047	.000	-5.6591	-4.5992
	Bottom	-3.24833*	0.26047	.000	-3.7783	-2.7184
Middle	Top	5.12917*	0.26047	.000	4.5992	5.6591
	Bottom	1.88083*	0.26047	.000	1.3509	2.4108
Bottom	Top	3.24833*	0.26047	.000	2.7184	3.7783
	Middle	-1.88083*	0.26047	.000	-2.4108	-1.3509

*. The mean difference is significant at the 0.05 level. Sig. (P-Value = 0.000) shows high significance (P- value far less than 0.05).
Dependent variable: Maize weight loss

3.3. Maize Weevil Management and Control Practices

3.3.1. Characteristics of the Farmers

The majority of the respondents (78.3%) were males. The age and family size of majority of the maize farmers was between 31-40 years and 1-5 persons in that order. The majority of the farmers (48.9%) undergone elementary education followed by illiterate group (40.8%). The demographic information of respondents is presented in Table 4.

Table 4. Demographic information of the respondents.

No.	Demographic information	Total (n = 360)
1	Gender	
	Male	282 (78.3)
	Female	78 (21.7)
2	Age category	
	18-30	59 (16.4)
	31-40	116 (32.2)
	41-50	88 (24.4)
	Above 50	97 (26.9)
3	Family size	
	1-5	208 (57.8)
	6-10	148 (41.1)
	Above 10	4 (1.1)
4	Educational level	
	None	147 (40.8)
	Primary	176 (48.9)
	Secondary	36 (10.0)
	Tertiary	1 (0.3)

3.3.2. Self-reported Maize Production and Post-harvest Maize Grain Loss

Table 5 shows self-reported quantity of maize produced during the most recent harvest year and causes of post-harvest loss. The majority of the farmers (34.7%) produced above 18 quintals of maize during the most recent harvest season. Maize weevil was reported to be the major cause of post-harvest maize grain loss by majority of the farmers (72.2%).

Table 5. Self-reported Maize production rate and Maize grain loss in AZK in 2019.

No.		Total (n = 360)
1	Quintal of maize harvest per year	
	5-12	123 (34.2)
	13-18	112 (31.1)
	Above 18	125 (34.7)
2	Causes of maize grain loss in the area	
	Maize weevil	260 (72.2)
	Theft	20 (5.6)
	Rodent	71 (19.7)
	Other	9 (2.5)

3.3.3. Maize Weevil Management Practices

Most of the farmers (55.6%) store their maize grain in bags followed by Gota (34.7%) a local container made from mud (Figure 1). Chemical insecticides were the most widely used method of maize weevil control by the farmers (98.1%), while a few (5.6%) used cultural methods such as sun-drying and ash (Table 6).

Table 6. Maize storage structures and weevil control practices in AZK in 2019.

No	Items	Total (n = 360)
1	Maize storage structures	
	Bags	200 (55.6)
	Clay pot	35 (9.7)
	Gota (local container made from mud)	125 (34.7)
2	Maize weevil control practices	
	Use of chemical insecticides	353 (98.1)
	Use cultural methods such as sun-drying, ash, *etc.*,	7 (5.6)

Figure 1. Typical Maize (*Zea mays* L.) Storage Structures (Bag Stores left and Gota; a mud store right) in Adet Zuria Kebele (Photo by Yilma Nibret in 2019).

4. Discussion

The ultimate purpose of the study was to determine the infestation status of the maize weevil and extent of maize grain weight loss that have occurred among small-holder farmers who use traditional storage structures and assess the pest management practices of the farmers as well. The study found that infestation rate of the maize weevil, *Sitophilus zeamays* in stored maize sample taken from bag store after seven months post-harvest storage was 79.5% in Adet Zuria Kebele. The current finding is in agreement with previous studies [5, 11, 12] who reported high infestation (>40%) of maize grain by the maize weevil in traditional storage structures in Ethiopia. The high infestation rate of the pest in the study setting may be influenced by storage duration, storage type and management practice experienced by the farmers [5].

The estimated weight loss due to maize weevil infestation ranged from 1.46% in the bottom portion to 2.95% in the middle portion of the bag store. This result is lower than the weight loss report from a similar traditional storage structure in Jimma Zone that varied from 41 to 80% [11]. The variation in weight loss of the stored maize caused by the maize weevil between the present and the previous report could be attributed to differences in agro-ecological variation [5]. The present study was conducted at higher altitude (2238m. a. s. l.) where the local temperature and the weevil activities are lower as compared to the previous study in Jimma Zone (880 m.a.s.l.) where the temperature and the pest activities are higher. Maize weevils are extremely destructive to maize under favorable condition of tropic and sub tropic temperature driven by local agro-ecological variations [5]. A similar study elsewhere in Africa also reported lower maize weight loss due to *S. zeamais* that ranged from 9.5% in the bottom portion to 15. 3% in the middle portion of bag store [13].

The mean weight loss of maize at the top, middle and bottom portions of the bag store was statistically different with significantly higher mean weight loss of maize at the middle of the bag store as compared to either the top or bottom portions of the bags. This finding agrees with previous report by [13] who observed that the number of maize weevil and weight loss at the middle of the bag store was larger as compared to the top and the bottom. This can be explained by micro-climatic variations within the bag store. There might be optimum temperature and humidity which is suitable for maize weevil activities which in turn increases the weight loss of the maize at the middle.

According to the farmers, the major cause of post-harvest loss of maize in Adet Zuria Kebele is the maize weevil (*S. zeamais*). This is consistent with previous studies from other parts of Ethiopia [4, 11, 12, 6]. This pest is considered most destructive to stored maize grains in Ethiopia [4, 11, 14].

Most of the farmers (90.3%) store their maize grain in traditional storage structures particularly in bags and gota. The maize storage structures reported in the current study coincide with those observed by other workers who reported that in Ethiopia, grain storage practices involve traditional structures, which are largely ineffective in the prevention of the stored products [5, 11, 12]. The majority of farmers in Ethiopia use traditional storage containers that expose stored grains to storage insect pest, mold and other loss factors [12].

Chemical insecticides were the most widely used method of maize weevil control by the farmers (98.1%), while a few (5.6%) used cultural methods such as sun-drying and ash. This observation corroborates with several previous reports [4, 5, 11, 14, 6]. Conventional synthetic insecticides are the chief weapon in the fight against the weevil infestation in stored maize in Africa including Ethiopia [15]. Insecticides potentially help farmers boost productivity significantly, particularly in Ethiopia where modern input uptake has historically been limited and crops yields low. But the use of insecticides may also incur risks of negatively affecting human health or the surrounding environment thereby decreasing net growth in productivity and well-being in the short and longer run [17]. While insecticides have been credited for their efficacy as compared to cultural control methods, they are increasingly receiving negative publicity due to high cost, health and environmental risks [6, 16]. The use of chemical insecticides to protect grain could lead to the increase in the risk of contamination of the home environment, pesticide residues in meals thereby increasing health risks to consumers. This highlights the importance of identifying and promoting safer and low cost locally available alternatives to the synthetic products for the control of maize weevil.

5. Conclusion

Results underscore that the infestation rate of the maize weevil in stored maize in Adet zuria Kebele was very high. The farmers store their maize in traditional storage structures namely bag store and gota and rely on chemical insecticides for protection of the maize weevil infestation. Therefore integrated maize weevil management actions should be undertaken that include improvement of traditional storage system and ecofriendly management of storage insect pests of maize in the study setting there by reduction in infestation, grain damage and post-harvest losses.

Acknowledgements

The authors of this manuscript are deeply grateful to Adet Zuria kebele maize farmers for their hospitality and provision of necessary data for the study. The authors also acknowledge Wollega University Department of Biology for proving field facilities.

References

[1] FAO (2002) FAO Global Early Warning System on Food and Agriculture: FAO/WFP Crop and Food Assessment Mission to Zimbabwe. FAO Publications, Harare, Zimbabwe. pp. 1–3.

[2] Bbosa D (2014) "Pesticide free methods of maize weevil control in stored maize for developing countries". *Graduate Theses and Dissertations*. 14083. https://lib.dr.iastate.edu/etd/14083.

[3] Kebede M, Gezahegn B, Benti T (1993) Maize production trends and research in Ethiopia. pp. 4-12. In: Ranson JK, Benti T (eds.). Proceedings of the First National Maize Workshop of Ethiopia. 5-7 May 1992, Institute of Agricultural Research, Ethiopia.

[4] Demissie G, Tefera T, Abraham TA (2008) Importance of husk covering on field infestation of maize by *Sitophilus zeamais* Motsch (Coleoptera: Curculionidae) at Bako, Western Ethiopia. African Journal of Biotechnology, 7:3777-3782.

[5] Dubale B, Waktole S, Solomon A, Geremew B, Setu MR (2012) Influence of Agro-ecology, traditional storage containers and major insect pest on stored maize (Zea mays L.) in selected woredas of Jimma zone. Asian Journal of Plant Science, 11: 226-234.

[6] Demmirew SK, Edosa TT, Gutema EA. (2018) Ecofriendly management of storage insect pests of maize in Jimma Zone. International Journal of Advanced Scientific Research, 3:34-38.

[7] Ileleji KE, Maiera DE, Woloshuk CP (2007) Evaluation of different temperature management strategies for suppression of *Sitophilus zeamais* (Motschulsky) in stored maize. Journal of Stored Products Research, 43:480–488.

[8] Yuya AI, Tadesse A, Tefera T (2009) Efficacy of combining Niger seed oil with malathion 5% dust formulation on maize against the maize weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae). Journal of Stored Products Research, 45:67–70.

[9] Trematerra P, Valente A, Athanassiou CG, Kavallieratos NG (2007) Kernel-kernel interactions and behavioural responses of the adult maize weevil *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). Applied Entomology and Zoology, 42: 129-135.

[10] Gewinner J, Harnisch R, Muck O (1996) Manual on the prevention of postharvest grain losses. GTZ, Eschborn, Germany.

[11] Sori W, Ayana A (2012) Storage pests of maize and their status in Jimma Zone, Ethiopia. African Journal of Agricultural Research, 7:4056-4060.

[12] Tadeos S. (2018). Occurrence of stored grain insect pests in traditional underground pit grain storages of Eastern Ethiopia. Agricultural Research & Technology: Open Access Journal, 13(2): 555879. DOI: 10.19080/ARTOAJ.2018.13.555879 0046.

[13] Baidoo PK, M. B. Mochiah and M. Owusu Akyaw (2010) Levels of Infestation on Three Different Portions of the Maize Cob by the Weevil *Sitophilus zeamais* (Motschulsky) Journal of Science and Technology, Vol. 30: pp 21.

[14] Wale M, Mengie T (2017) Effect of organic products (Lupine oil and Areki) against maize weevil (*Sitophilus zeamais*) on stored maize grains (*Zea mays*). International Journal of Entomology Research, 2:79-84.

[15] Tadele S, Mulugeta N (2017) Determination of the Appropriate Doses of Promising Botanical Powders against Maize Weevil, *Sitophilus zeamais* Mots (Coleoptera: *Curculionidae*) on Maize Grain. Agricultural Research & Technology: Open Access Journal, 6:555698. DOI:10.19080/ARTOAJ.2017.06.555698. 00107 Ag.

[16] Nwosu LC (2016) Chemical bases for maize grain resistance to infestation and damage by the maize weevil, *Sitophilus zeamais* Motschulsky. Journal of Stored Products Research, 69: 41–50.

[17] Damalas CA, Eleftherohorinos IG (2011) Pesticide exposure, safety issues, and risk assessment indicators. International Journal of Environmental Research and Public Health, *8:*1402-1419.