Effects of Maize Weevil *Sitophilus zeamais* (Motschulsky) (Coleopteptera: Curculionidae) on Grain Damage and Weight Loss of some Maize (*Zea mays*) Genotypes in Yola, Adamawa State

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ABSTRACT

This study was conducted to determine the effect of Sitophilus zeamais on grain damage and weight loss of some maize genotypes under controlled storage using transparent jars of 1.5 litre capacity at ambient temperature of 20 ± 25°C and 65± 70% relative humidity, at the Department of Crop Production and Horticulture laboratory, Modibbo Adama University of Technology, Yola, Adamawa State. The experiment consists of twenty five treatments which include twenty improved maize varieties and five local cultivars. The twenty (20) improved maize varieties are SAMMAZ 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 25, 26, 27, 29, 30, 33, 34, 37 and 38, and were obtained from Institute for Agricultural Research, Ahmadu Bello University (ABU), Zaria, Kaduna State, and five local cultivars namely; Boderi, Saksi, Baleri, Maijanbaki and Daneri were obtained from local grain market, Yola. Fifty (50) unsexed adult weevils were introduced to each jar to infest 250 g of maize grains to evaluate the resistance and the susceptibility of these maize varieties/cultivars in Yola to S. zeamais based on susceptibility index. The experiment was laid in Completely Randomized Design (CRD), replicated three times. Grain damage and weight loss were evaluated. Weevils fed with Boderi, Saksi, Baleri, Maijanbaki and Daneri produced lower grain damage, and weight loss, high adult mortality of maize weevil, and high median developmental time while SAMMAZ 33, 19, 37, 34, 15, 16, 17, 29, 25, 20, 27, 30, 38, 26, 22, 18, 21, 13, 11 and 14 had short median developmental time, an increasing numbers of F_1 progeny resulted in increasing grain damage, low adult mortality of maize weevil and weight loss. These results indicated that S. zeamais has great impact on the improved varieties than the cultivars tested during the experiment.

Key Words: Maize, Variety, Cultivar, Resistant, Susceptible, Grain Damage, *Sitophilus zeamais*.

INTRODUCTION

The maize weevil, *Sitophilus zeamais*, is the most destructive pest of stored maize. It belongs to Coleoptera order and family Curculionidae. It has 2-to 4-mm body length with its 6 head protruded into a snout. At the end of the snout, there is a pair of mandibles. It is generally reddish brown in color. It has a long snout with clubbed segmented elbowed antennae and four light reddish brown oval spots on the elytra (Khare, 1994). The lifecycle is on average 36 days at 27±10C, and 69±3% relative humidity (RH) (Sharifi and Mills, 1971). Maize weevils can be extremely economically destructive to maize under good conditions of tropic and sub-tropic temperatures and maize moisture content ranges of 10 to 14%. Adult weevils damage grain by feeding on the endosperm of the grain kernel. The female deposits an egg on a kernel, eggs hatch into larva (tiny grubs) which feed on the endosperm inside the kernel (Hill, 1983). This impacts the quality of the grain in terms of bulk density, moisture content and endosperm value while also producing significant grain dust (maize components in powder form). When not controlled, weevils will completely consume all components inside the maize kernel during storage. Exposure due to damage inflicted on the kernels also facilitates disease and fungal growth in the grain (CGC, 2013). Factor variety differences within grains have been reported to affect the development time and reproductive capacity of maize weevils (Adams, 1976; Dobie and Kilminster, 1978; Gomez *et al.*, 1983).

Maize is the most important cereal crop in sub-Saharan Africa (SSA) and an important staple food for more than 1.2 billion people in SSA and Latin America. All parts of the crop can be used for food and non-food products. In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products (IITA, 2016). Storage of maize by smallholder farmers have been well documented and categorized by FAO (2009, 1994) into: a) traditional farm/village storage methods which include: temporary storage methods (aerial storage, ground or drying floor storage, open timber platforms), long-term storage (basket storage, calabashes, gourds, earthenware pots, jars, solid wall bins, underground storage), b) 'improved' farm/village storage methods: these are meant to address weaknesses of traditional farm/village storage methods and c) alternative storage technology (other than traditional and improved traditional systems) at farm/village level such as: metal or plastic drums, alternative solid wall bins e.g. "USAID" bin, concrete silo, "Pusa" bin, metal silos and synthetic silos. Moussa *et al.*, (2011) reports that storage level technology acceptance is highly significant in countries that receive specific training compared to those that do not though in non-trained countries, other approaches such as general extension services can be used.

In developed countries and in particular the U.S., most cereals are stored in commercial grain elevators. Monitoring of grain temperature and calendar-based fumigations using phosphine are among the control measures taken for insects in grain elevators (Hagstrum *et al.*, 1999). Bins can be built from steel or concrete. In comparison, steel bins are built with aeration fans whereas large upright concrete bins are frequently not built with them (Flinn *et al.*, 2007). Insects in upright concrete bins are controlled through fumigation and turning of grain to add aluminum phosphide pellets. U.S. cereals like wheat are not infested in the field (Cotton and Winburn, 1941).

The increased public awareness and concern for environmental safety has directed research to the development of alternative control strategies such as the use of resistant maize varieties against *S. zeamais*. According to (Adedire and Lajide, 2003) the resistant varieties provide practical and economical ways to minimize losses to insect pests. Therefore, the potential impact on food security, poverty reduction and greater livelihood security will not be realized, however, if farmers are unable to store grains and sell surplus production at attractive prices. It is a known fact that one of the important problems which are on the increase in post-harvest handling is losses to storage insect pests such as the maize weevil, *S. zeamais* which is one of the major pests of stored maize in Yola, Adamawa State - Nigeria. To address this problem however, cheap and effective method for reducing *S. zeamais* damage to stored maize is needful, since damaged grains have reduced weight and germination percentage respectively. This research work therefore, is designed to find out the potentials of inherent resistant of some varieties of maize in storage to *S. zeamais* in Yola, Adamawa State, Nigeria.

MATERIALS AND METHODS

The experiment was conducted at the laboratory of Department of Crop Production and Horticulture, Modibbo Adama University of Technology, Yola, under ambient temperature of 20 ± 25°C and 65± 5% relative humidity. The Department of Crop Production and Horticulture laboratory is located at Latitude 9° 20' 49" North and Longitude 12° 29' 42" East at an altitude of 196m above sea level.

The maize genotypes were obtained from Institute for Agricultural Research (IAR)/Ahmadu Bello University (ABU), Zaria, Kaduna State, Nigeria and five local cultivars were procured from local grain market Yola, Adamawa State. These varieties are currently under production in different parts of Yola and beyond. The experiment consists of twenty five treatments which include twenty varieties and five cultivars. The experiment was laid in Completely Randomized Design (CRD), replicated three times.

Initial Multiplication of S. zeamais

Unsex adults *S. zeamais* were locally obtained from naturally infested maize grains from local grain market in Yola, Adamawa State, for the experiment, following the reports of (Odeyemi and Daramola, 2000), was introduced into, and reared on a local maize grain (Daneri) in 4 transparent jar, of 1.5 l capacity, containing 250 g maize grain cleaned to remove grains with visible damage symptoms each after disinfesting it by keeping it in the oven at 60°C for two hours (Derera *et al.,*2001). Thereafter, they were brought out to be acclimatized before use. After acclimatization, 50 emerged unsexed adult weevils were introduced to each jar to infest the 250 g of maize seeds. The jar were covered with muslin cloth and fixed with rubber band to prevent escape of weevils as well as to permit aeration under room temperature (21-23°C) and were kept for seven days for oviposition (Derera *et al.,* 2001). On the seventh day, the medium were sieved to enable the removal of the parents *S. zeamais* with a view to place on another fresh set of grain medium again and again until sufficient quantity of required weevils of similar and known age were acquired to conduct the experiment and were kept under laboratory conditions in an open air shelf. Grains of each variety were subjected under the same conditions without *S. zeamais* and will serve as control for the purpose of comparison. These observations were kept until all F1 progeny expected emerged and were used to conduct the experiment (Abebe *et al.,* 2009).

Data were collected on the following parameters:

Adult mortality of maize weevil: Adult mortality of maize weevil were assessed seven days after introduction of weevils by removing and counting both dead and alive of each jar on a piece of white cloth and removing the adults with a soft entomological brush.

***F_1 progeny of maize weevil*:** To further assess F_1 progeny emergence for the subsequent optimum period of thirty five days as well as adult mortality data assessment, all the dead and alive adult insects were removed from each jar and the grains of each tested variety were kept under the same experimental conditions under five-day interval for inspection with a view of removing the emerging progeny and counting them jar by jar on each assessment period of five-day interval for thirty-five days.

Assessment of damaged maize grains and weight loss: Thirty five days after introduction of the weevils, 100 maize grains were randomly taken from each jar. The numbers of damaged grains (holed grains) by weevil feeding were assessed. Damaged maize grains were then expressed as a proportion of the total number of grains sampled. Weight loss of maize grain was also determined using the count and weigh method.

Weight loss (%) = (Wu x Nd) - (Wd x Nu) X 100 / Wu x (Nd + Nu)

Where:

Wu = Weight of undamaged maize grains,
Nu = Number of undamaged maize grains,
Wd = Weight of damaged maize grains,
Nd = Number of damaged maize grains.

Data Analysis: All data collected from the experiment were subjected to Analysis of Variance (ANOVA) using SAS soft ware. Significant differences between means were separated using Duncan's Multiple Range Test (DMRT) at 5 percent level of significance ($P < 0.05$).

RESULTS

Assessment of Damaged maize grains: From the analysis of variance, grain damage were observed to be highly significant ($P \leq 0.01$) among the varieties/cultivars tested. Table 1 shows the mean performance in percentage on damaged grains among the varieties/cultivars tested. The highest damaged grains were observed in SAMMAZ 11 with the mean value of 34.00 percent, followed by SAMMAZ 20, SAMMAZ 21, and SAMMAZ 17 with the mean performances of 28.66, 25.33 and 22.66 percent, respectively. The lowest damaged grains were observed in maijanbaki with the mean value of 0.00 percent.

***Assessment of Undamaged maize grains*:** From the mean square of analysis of variance, undamaged grains were highly significant (P ≤ 0.01) among the maize varieties/cultivars used. The assessment of undamaged grains is presented on Table 1. The highest mean performance of percentage came from maijanbaki recording a mean value of 100.00 followed by Daneri and Boderi with the mean value of 99.66 each respectively, while the lowest mean value was recorded from SAMMAZ 11 with a mean value of 66.00. The remaining twenty one treatments fall within the ranges of the mean value of 71.33 to 98.66 percent, respectively.

***Weight of Undamaged maize grains*:** The mean performance in percentage on weight of undamaged grains is shown in Table 2. The mean square of analysis of variance on weight of undamaged seed was highly significant (P ≤ 0.01). The highest weight of undamaged grains came from SAMMAZ 15 with the mean value of 27.76 percent followed by Baleri which recorded 27.40 while the lowest mean value was observed from SAMMAZ 22 with mean value of 15.73 percentage, respectively. Other treatment lies between 17.86 to 25.70 percent, respectively.

***Weight of Damaged maize grains*:** Table 2 presented the mean performance in percentage on weight of damaged grains with the maximum mean value of 6.86 recorded from SAMAZ 11. The lowest value of mean performance was observed from maijanbaki recording a mean value of 0.00 percent, respectively. The mean value of other treatments tested fall within the ranges of 0.06 to 5.06 percent, accordingly. The mean square of analysis of variance on weight of damaged seed was highly significant (P ≤ 0.01).

***Assessment of weight loss on maize grains*:** From the mean square of analysis of variance, weight loss were highly significant (P ≤ 0.01) among the maize varieties/cultivars used. The mean performance in percentage on assessment of weight loss is shown on Table 2 where the maximum mean of performance percentage of 16.93 percent was recorded from Baleri, and the minimum mean values of 0.36, 0.4, 0.40 and 0.56 percents were observed from SAMMAZ 34, SAMMAZ 16, AMMAZ 26 and SAMMAZ 38 respectively. The mean values ranging between 1.10 to 5.50 percent covers other varieties/cultivars tested, respectively.

DISCUSSION

Maize in store with high index of susceptibility suffered seed damage, weight loss and germination percentage. These variables were significantly different among varieties tested. This is not unconnected with the damage caused by the inoculated maize weevils hence the variations. This account agree with Derera *et al* (2001) who asserted that the degree of weight loss has been found to be a reasonable measure of maize grain resistance or susceptibility to the maize weevil. Generally, high percentage of seed damage was observed on susceptible maize varieties, and this could be due to the attractiveness or conduciveness or the flavor, of such maize varieties to maize weevils. Meanwhile, undamaged maize seed were observed mostly in highly resistant varieties/cultivars tested. This could be attributed to hard grains (mechanical barriers) provided by thick testas and hard grains to the penetration of the endosperm by *S. zeamais* amongst the resistance exhibited by the varieties. The seed coat thickness and grain hardness served as a barrier to varieties which proved to be less susceptible to infestation as asserted by Lale and Kartay (2006).

CONCLUSION

This study has provided knowledge or basis for evaluating grain damage and weight loss, were weevils fed with Boderi, Saksi, Baleri, Maijanbaki and Daneri produced lower grain damage, and weight loss, high adult mortality of maize weevil, and high median developmental time. These results indicated that *S. zeamais* has great impact on the improved varieties than the cultivars tested during the experiment. It can therefore, be concluded from the result obtained that there exist differential reaction of different maize varieties. Though the most successful are local cultivars, the success may not be unconnected with their morphological and biochemical constituents and other physical factors that brought about the success whereby Boderi, Saksi, Baleri, Maijanbaki and Daneri were cultivars with less adult mortality, indices of susceptibility, weight loss, and number of undamaged seed. These indices, pointing to the overall loss incurred to these varieties during storage will be minimal as compared to other varieties available in the state.

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Table 1: Mean Performance in Percentage on Assessment of damaged and undamaged seed, Weight of damaged and undamaged seed, and Weight loss by *S.Zeamais*

Variety	damaged seed	undamaged seed
SAMMAZ 11	34.00a	66..00i
SAMMAZ 13	10.66ef	89.33fe
SAMMAZ 14	7.66fg	92.33de
SAMMAZ 15	2.00hij	98.00abc
SAMMAZ 16	1.33ij	98.66abc
SAMMAZ 17	22.66cd	77.33gh
SAMMAZ 18	2.33hij	97.66abc
SAMMAZ 19	5.33ghi	94.66bcd
SAMMAZ 20	28.66b	71.33i
SAMMAZ 21	25.33cb	74.66hi
SAMMAZ 22	19.00d	81.00g
SAMMAZ 25	4.33g-j	95.66a-d
SAMMAZ 26	5.33ghi	94.66bcd
SAMMAZ 27	6.66fgh	93.33cde
SAMMAZ 29	1.33ij	98.66abc
SAMMAZ 30	2.33hij	97.66abc
SAMMAZ 33	2.33hij	97.66abc
SAMMAZ 34	5.33ghi	94.66bcd
SAMMAZ 37	2.66hij	97.33abc
SAMMAZ 38	13.66e	86.33f
Saksi	4.33g-j	95.66a-d
Baleri	3.00hij	97.00abc
Daneri	0.33j	99.66a
Maijanbaki	0.00j	100.00a
Boderi	0.33j	99.66a
Pr > F	0.01	0.01

Means in the same column with the same letters are not significantly different at 5 percent of significance ($P < 0.05$).

Table 2: Mean Performance in Percentage on Assessment of Weight of damaged and undamaged seed, and Weight loss by *S.Zeamais*.

Variety	Weight of damaged seed	Weight of undamaged seed	Weight Loss
SAMMAZ 11	6.86a	18.16gh	4.23cde
SAMMAZ 13	2.73b-e	24.56abc	1.40ih
SAMMAZ 14	1.76b-e	25.66ab	4.23cde
SAMMAZ 15	0.73de	27.76a	1.10ih
SAMMAZ 16	0.26e	25.50abc	0.40i
SAMMAZ 17	3.00b-e	17.86gh	2.00ghi
SAMMAZ 18	0.83de	18.43fgh	2.03ghi
SAMMAZ 19	4.36a-d	20.80d-g	1.23ih
SAMMAZ 20	4.83abc	23.43b-e	2.90e-h
SAMMAZ 21	5.06ab	17.93gh	3.46d-g
SAMMAZ 22	2.86b-e	15.73h	0.56i
SAMMAZ 25	1.10cde	17.96gh	1.40ih
SAMMAZ 26	3.73a-e	23.70b-e	0.40i
SAMMAZ 27	2.03b-e	23.13b-e	2.23f-i
SAMMAZ 29	0.20e	24.33a-d	1.93ghi
SAMMAZ 30	0.60ed	25.40abc	1.96ghi
SAMMAZ 33	0.50ed	24.76abc	2.76e-h
SAMMAZ 34	0.70de	21.86c-f	0.36i
SAMMAZ 37	0.60ed	25.70ab	2.06f-i
SAMMAZ 38	2.36b-e	18.73fgh	0.56i
Saksi	4.40a-d	22.43b-e	6.56b
Baleri	0.53ed	27.40a	16.93a
Daneri	0.06e	20.30efg	4.00c-f
Maijanbaki	0.00e	22.23b-e	5.50bc
Boderi	0.10e	25.06abc	5.03bcd
Pr > F	0.01	0.01	0.01

Means in the same column with the same letters are not significantly different at 5 percent of significance ($P < 0.05$).