EVALUATION OF PROXIMATE COMPOSITION OF MAIZE GRAINS INFESTED BY MAIZE WEEVIL (*SITOPHILUS ZEAMAIS* L.) (COLEOPTERA: CURCULIONIDAE)

A. A. Osipitan*, O. K. Olaifa* and O. A. Lawal**

* Department of Crop Protection, University of Agriculture, Abeokuta, Ogun State, NIGERIA. E-mail: osipitan1@yahoo.com
** Department of Plant Science and Applied Zoology, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, NIGERIA.

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ABSTRACT: The study examines change in the proximate composition of maize grains infested by varied population of maize weevil (*Sitophilus zeamais*). 50 gm maize grains (SUWAN-1) was weighed into 250 cm^3 Kilner glass jars and separately infested with 5pairs, 10 pairs and 15 pairs of *S. zeamais* for ninety days. A 250 cm^3 Kilner jar filled with 50 gm uninfested maize grains served as control. All treatments and control were replicated four times and arranged on the work-table in the laboratory using completely randomized design. At 90 day post-infestation of the maize grains, data were collected on damage indices such as % grain weight loss, % grain damage, weight of grain dust and final population of *S. zeamais*. The proximate composition of the damaged and undamaged maize grains was determined by analyzing the maize grains for total protein, fat, starch, sugar, moisture and ash contents using the standard analytical method (AOAC, 1970). The data on proximate analysis was correlated with final population of *S. zeamais*, weight of grain dust, % grain weight loss and % grain damage. The results indicated that *S. zeamais* infestation of maize grains had a significant ($P < 0.05$) effect on protein, starch and moisture content of the infested maize grains. The damage to maize grains and depletion of its proximate composition directly correlated with the population of *S. zeamais*. Adequate preservation of stored maize grains from infestation by *S. zeamais* is therefore essential to reduce loss during storage and depletion of nutritional composition of stored maize grains.

KEY WORDS: *S. zeamais,* proximate composition, infestation, damage indices.

Maize – *Zea mays* is the third most important cereal crop after rice and wheat (CIMMYT, 1994). It has the widest distribution and is primarily grown for its grains which is consumed as human food and animal feed. The crop is high yielding, mature early, easy to process, readily digestible, cost less than other cereals and can be grown across a range of agroecologocal zones (Enyong et al., 1999). In some developed countries, maize is also grown for industrial products such as oil, syrup and starch (CGIAR, 1996). The diverse usefulness of maize has led to increase in maize production and reversed the downward spiral of food production in Africa. The world maize output was 301 million tonnes in 1992, but increased to 589million tonnes in 2000. The United State of American produces 43%, Asia (25%), Latin America and Caribbean (13%) and Africa (7%) of the production in 2000.

The production of maize and yield is however threatened by insect pest that infest the crop on the field and in the store. *S. zeamais* are the major primary insect pest of stored maize grains throughout the warmer part of the world. Typical infestation of maize by *S. zeamais* starts on the field and transferred to the store where population builds up and cause greater damage to the maize grains (Howe, 1963; Hall et al., 1999). The growth and development of the insect in storage is favourably enhanced by suitable ambient temperature and relative humidity. Hall (1963) reported that 80% of stored maize grains are attacked on the field by *S. zeamais* and the infestation caused 10–15 % loss after 4-5 months due to build up of the insect. White (1953) estimated 20% loss in kernels of wheat after 5 weeks due to infestation by maize weevil larvae. *S. zeamai*s is highly destructive and could completely destroy grains in elevation, bins, ships and other places where physical conditions for growth are favourable. *S. zeamai*s feeds and lay eggs in the maize kernel; complete their larval and pupal stages within the kernels. These activities involve boring and generation of grain dust which may affect the nutritional composition of maize kernel. Adem and Bourges (1981) and Torreblanca et al. (1983) reported 30% changes in the concentration of the amino acids, lysine and tryptophan in maize grains infested by larger grain borer (LGB) - *Prostephanus truncatus*. Osipitan et al. (2009) also reported the ability of LGB to introduce fungi such *Aspergillus niger, A. tamari, A. parasiticus, A. ochraceus, Fusarium compacticum* and *F. oxysporium* and bacteria such *Bacillus cereus, B. macerans, Proteus mirabilis, P. morganic, P. rettgeri, Proteus* sp., *Pseud geniculatum, P. fragii, P. putela, Serratia marcences* into infested host through their frass This study therefore examines change in the proximate composition of maize grains infested by varied population of maize weevil (*Sitophilus zeamais*).

MATERIALS AND METHODS

The study was conducted at the Entomological Research Laboratory of the Department of Crop Protection, College of Plant Science and Crop Production, University of Agriculture Abeokuta (UNAAB). The maize weevil – *Sitophilus zeamais* used for the study was obtained from the culture maintained in the Department of Crop Protection, University of Agriculture, Abeokuta (UNAAB) and cultured in shelled maize grains in 500cm^3 capacity Kilner glass jars. Several adults of mixed sexes and unknown ages were introduced into the culture media. Frass generated by feeding activities of the insects was sieved out on weekly basis using sieve of mesh size 0.25 mm to prevent excessive grain moisture content and growth of mould. Culture media were rejuvenated monthly to replace depleted ones, and adults were sieved out to set up new culture to guarantee regular source of insect.

Experimental procedure

50 gm uninfested maize grains were weighed into 250 cm^3 Kilner jars using Mettler weighing balance. Varied population of 5-10 days old *S. zeamais* was introduced into the jars as follows:

50 gm maize grains + 5 pairs *S. zeamais*
50 gm maize grains + 10 pairs *S. zeamais*
50 gm maize grains + 15 pairs *S. zeamais*
50 gm maize grains + No *S. zeamais* (Control)

The insects were sexed using the methods of Haines (1991). Each treatment was replicated four times and arranged on work-table in the laboratory using Completely Randomized Design (CRD).

50 gm maize grains were weighed into 250 cm^3 Kilner jars to monitor change in weight of grains as a result of moisture loss or gain (Hurlock, 1967). At 90 day post-infestation, the insects and the grain dust they generated by their feeding activities were sieved out of the grains and they were separated into damaged and undamaged and the following data were taken:

(i) Number of adult *S. zeamais*
(ii) Number of adult mortality

(iii) Weight of dust (gm)
(iv) Weight of damaged and undamaged grains
(v) Final weight of grains

Insects that did not move or respond to three probing with a blunt probe were considered dead (Obeng-Ofori & Reichmuth, 1997). Percentage weight lost and percentage damage respectively were calculated using the formulae, according to Baba Tierto (1994).

$$\% \text{ GWL} = \frac{\text{WCS} - \text{FWG} \times 100}{\text{WCS}}$$

GWL = Grain weight loss,
WCS = Weight of control sample,
FWG = Final weight of grains

$$\% \text{ GD} = \frac{\text{WDG} \times 100}{\text{WDUG}}$$

GD = Grain damaged,
WDG = Weight of damaged grains,
WDUG = Weight of damaged and undamaged grains

Determination of proximate composition of damaged grains

Proximate composition of damaged grains in each of the treatments and the undamaged grains (control) was determined by analyzing them for total protein, fat, starch, sugar, moisture and ash using the standard analytical method (AOAC, 1970). The data on proximate composition were also correlated with final population of *S. zeamais*, weight of grain dust, percentage grain weight loss and % grain damage.

Statistical analysis

Statistical analysis of data was based on SAS's general linear models procedure (SAS Institute, 2001). The data were subjected to Analysis of Variance (ANOVA). Significant means were compared using Student's Newman-Keuls Test (SNK) at $P < 0.05$.

RESULTS

Grain damage parameters

The final population (145.75) of *S. zeamais* from maize grains infested with 15 pairs of the insect was significantly ($P < 0.05$) higher than insect population from maize grains infested with 5 pairs. It was however, not significantly ($P > 0.05$) different from 144.00 *S. zeamais* from maize grains infested with 10 pairs of *S. zeamais* (Table1). As shown on Table1, the weight of grain dust (0.43 gm) was significantly ($P < 0.05$) lower in maize grains infested with 5 pairs of *S. zeamais*. The weight of grain dust (0.88 gm) was highest in maize grains infested with 15 pairs of *S. zeamais*. It was however, significantly ($P > 0.05$) comparable with weight of grain dust (0.79 gm) from maize grains infested with 10 pairs of *S. zeamais*.

The lowest grain weight loss (5.94%) was from maize grains infested with 5 pairs of *S. zeamais* and it differed significantly ($P < 0.05$) from weight loss of 10.21% from maize grains infested with 15 pairs of *S. zeamais*. The weight losses of 5.94% and 10.21% from maize grains infested with 10pairs and 15 pairs of *S. zeamais* respectively were not significantly ($P > 0.05$) different from each other (Table 1). The maize grains infested with 5 pairs of *S. zeamais* had a significantly ($P < 0.05$) lower % grain damage (54.23). The % grain damage from maize grains infested with 10 and 15 pairs of S. *zeamais* was 70.19 and 79.60 respectively. They were however not significantly ($P > 0.05$) different from each other (Table 1).

Proximate composition of damaged grains

As shown in Table 2, the proximate compositions of the maize grains at the different population of *S. zeamais* varied. The protein content (10.73) in the uninfested maize grains (control) was highest, but compare significantly ($P > 0.05$) with protein contents of 10.55 and10.05 from maize grains infested with 5pairs and 10 pairs of *S. zeamais* respectively. The protein content (9.65) of maize grains infested with 15 pairs of *S. zeamais* was the lowest, but compare significantly ($P > 0.05$) with protein contents (10.05) in maize grains infested with 10 pairs of *S. zeamais*.

The Moisture content of infested and damaged maize grains at all the population levels of *S. zeamais* infestation differ significantly ($P < 0.05$) from the moisture content of uninfested maize grains (control). The moisture content (12.60) of maize grains infested with 15 pairs of *S. zeamais* was significantly ($P < 0.05$) higher than moisture content in other *S. zeamais*-infested maize grains. The moisture contents (10.50 and 10.88) of maize grains infested with 5 pairs and 10 pairs of *S. zeamais* respectively were not ($P > 0.05$) significantly different from each other. Table 2 shows some depletion in starch content of *S. zeamais*-infested maize grains. The starch content of the damaged maize grains at all population level of *S. zeamais* infestation was significantly ($P < 0.05$) lower than the starch content of the undamaged maize grains. The lowest starch content (67.77) was in maize grains infested with 15 pairs of *S. zeamais*. It however, compare significantly ($P > 0.05$) with starch contents of 70.50 and 69.50 in maize grains infested with 5 pairs and 10 pairs of *S. zeamais* respectively. Irrespective of the population level of *S. zeamais* infestation, the composition of ash, fat and sugar were not significantly ($P > 0.05$) different from each other and from the uninfested maize grains.

Correlation of proximate composition of damaged maize grains and damage indices

The correlation (0.981) between % grain weight loss and % grain damage was positive and significant. Likewise, the correlation between final population of *S. zeamais* and % grain damage (0.975), final population of *S. zeamais* and % grain weight loss (0.958), % grain weight loss and weight of grain dust (0.701) were positive and significant (Table 3). The correlation between final population of *S. zeamais* and protein content (-0.682), % grain damage and protein content (-0.690), % grain weight loss and protein content (-0.752) were negative and significant (Table3).

DISCUSSION

In this study, maize grains infested with the higher population of *S. zeamais* had the highest grain weight loss and grain damage. This result is similar to the results of Arnarson et al. (1994) that reported variation in the damage to some infested maize grains by *S. zeamais*. The significant reduction in protein and starch content of maize grains infested by *S. zeamais* suggest depletion of these nutrients as a result of infestation by the insect. Adem & Bourges (1981) and Torreblanca et al. (1983) studied changes in the nutritional composition of maize grains infested by the larger grain borer (LGB) – *Prostephanus truncatus*, a storage insect pest of maize and reported 30% decline in the concentration of amino acids, lysine and tryptophan. In a similar study on nutritional depletion of maize kernel by *S. zeamais*, Dobie & Kilminster (1978) reported protein as an important nutrient in the diet of insect pest. The significant negative correlation of grain damage with protein content of damaged grains suggests that protein is one of the nutrients affected by the insect feeding.

In this study, the moisture content of infested and damaged maize grains increased. This may be as a result of the boring and other metabolic activities of the insect in infested grains. These activities will generate heat required for chemical reactions that proceed more frequently and rapidly at higher temperature with release of moisture as one of the bi-products of reactions. The results of this study is in agreement with the findings of Hayward et al. (1955) which reported surface heating, dampness and increase in moisture content of wheat- *Triticum aestivum* infested by *S. zeamais*.

In this study, the weight of grain dust obtained from infested maize grains directly vary with the population level of *S. zeamais*, grain weight loss and grain damage. This suggests that damage was done to the maize grains was as a result of the boring activities of the insect and conversion of maize grains to dust.

The results of these studies shows that *S. zeamais* is a highly destructive storage insect pest that could cause grain weight loss of between 5.94%, and 10.21%, grain damage of between 54.23%, and 79.60% in infested maize grains within 3 months. The results also show the ability of the insect to increase the moisture content of infested maize grains and cause reduction of starch and protein content. Conscious and concerted effort should therefore be made at preserving stored maize grains from infestation by *S. zeamais* to reduce loss in quantity and quality.

LITERATURE CITED

Adem, E. & Bourges, H. 1981. Cambios en la concentration de algunos components del grano de maize infestado por *Prostephanus truncatus* Horn, *Sitophilus zeamais* Mots, and *Sitotroga cerealella*, Oliver. Archs lat. Am. Nutr., 31: 270-286.

AOAC 1990. Official methods of analysis of the Association of Official analytical Chemists, 15th Edition, AOAC, Arlington, Virginia.

Baba-Tierto, N. 1994. Ability of powder and sluries from ten plant species to protect stored grains from attack by *Prostephanustruncatus* (Horn) (*Coleoptera: Bostrichidae*) and *Sitophilus oryzae* (L). (*Coleoptera: Curculionidae*). J. Stored Prod. Res., 30: 297–301.

CGIAR 1996. Phenomenal Increase in Maize Production in West and Central Africa. Consultative Group on International Agricultural Research Newsletter, 3 (1): 2-3.

CIMMYT 1994. World maize facts and trends. Maize seed industries revisited: Emerging roles of the public sector.

Dobie, P. & Kilminster, A. M. 1978. The susceptibility of triticate to post-harvest infestation by *Sitophilus zeamais* Mots., *Sitophilus oryzae* L. and *S. granaries*. J. Stored Prod. Res., 14: 87 -93.

Enyong, L. O., Adesina, A., Youri, A. & Raman, A. 1999. Dynamics of maize production, adoption of improved varieties and food security in the northern region of Cameroon Physical properties, 365 -376 in Badu-Apraku, B Fakorede.

Haines, A. 1991. Insects and arachnids of tropical stored products, their biology and identification.

Hall, A. B. 1963. Some essential considerations on the storage of food grains, cereals, legumes and oil seed in tropical Africa, FAO Agriculture Engineering information working Bulletin. No. 24.

Hayward, L. A. W. 1955. The effect of the infestation of wheat – *Triticum astivum* by *Sitophilus zeamais* on moisture content. J. Sci. Food Agric., 6: 337-340.

Howe, R. W. 1963. The random sampling of culture of grain weevils. Bull. Ent. Res., 54: 135-146.

Hurlock, E. T. 1967. Some observation on the amount of damage caused by *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvidae) to wheat. J. Stored Products Res., 3: 75-78.

Obeng-Ofori, D., Reichmuth, C. H., Bekele, J. A. & Hassanali, A. 1997. Biological activity of 1, 8 cineole, a major component of essential oil of *Ocimum kenyense* against stored product Coleoptera. J. Appl. Entomol., 121 (3): 169-173.

Osipitan, A. A., Akintokun, K., Odeyemi, S. & Bankole, S. O. 2009. Microbial counts and damage caused by larger grain borer – *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) infestation and damage on some commodities. Archives of Phytopathology and Plant Protection, GAPP A 321647 (Taylor and Francis, UK) (In Press).

SAS 2001. SAS users guide stastistics, 6th edition. SAS Institute Inc., Cary, NC.

Torreblanca, R. A., Adem, C. E. & Bourges, R. H. 1983. Losses caused by *Prostephanus truncatus* (Horn) in maize stored under controlled condition. p. 87–89. In: "Memorias del Coloquio International Sobre conservacion de semmillas y Granos Almancenados" (Moreno-Martinez, Retimerez-Martinez, eds.). 20–25 Octubre 1980, Oaxtepec, More los, Institute de Biologia, Universidad Macional autonona de Mexico, 51 pp.

White, G. D. 1953. Weight loss in stored wheat caused by insect feeding. J. Econ. Ent., 46: 609-610.

Table 1. Final population and damage indices of grains infested with *S. zeamais*.

	Final population and damage indices of grains±SE			
Initial insect Population level	Final insect population	Weight of grain dust (gm)	% Grain weight loss	% Grain damage
0	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
5 pairs	96.25±1.97^{b}	0.43±0.13^{b}	5.94±2.12^{b}	54.23±1.80c
10 pairs	144.00±2.00^{a}	0.79±0.11^{a}	8.79±0.09^{ab}	70.19±2.42a
15 pairs	145.76±2.00^{a}	0.88±0.01^{a}	10.21±0.11^{a}	79.60±3.10a

Mean values in the same column having the same superscript are not significantly different, P> 0.05(SNK).

Table 2. Proximate composition of maize grains infested with *S. zeamais*.

Initial insect Population level	% Grain damage	Proximate composition of maize grains±SE					
		Ash	Fat	Moisture	Total Protein	Starch	Sugar
0	0.00[b]	1.82±0.08[a]	4.31±0.14[a]	10.48±0.18[a]	10.73±0.27[a]	72.20±0.31[a]	4.86±0.15[a]
5 pairs	54.23±1.80[c]	2.15±0.26[a]	4.13±0.03[a]	10.50±0.15[b]	10.55±0.22[a]	70.50±2.12[b]	4.39±0.22[a]
10 pairs	70.19±2.42[a]	1.71±0.86[a]	4.29±0.09[a]	10.88±0.24[b]	10.05±0.24[ab]	67.50±2.20[b]	4.37±0.2[a]
15 pairs	79.60±3.10[a]	1.84±0.54[a]	4.19±0.12[a]	12.60±1.10[c]	9.65±0.14[b]	67.77±0.86[b]	4.23±0.16[a]

Mean values in the same column having the same superscript are not significantly different, P> 0.05(SNK).

Table 3. correlation of proximate composition of maize grains with damage indices.

	Proximate composition of maize grains and damage indices of maize grains									
	Protein	Fat	Sugar	Starch	Ash	Moisture Content	Final population of insect	% damage	% Weight loss	Weight of grain dust
Protein	1.00									
Fat	-0.319	1.00								
Sugar	0.209	0.249	1.00							
Starch	0.066	-0.144	0.603	1.00						
Ash	0.144	-0.112	-0.061	-0.40	1.00					
Moisture content	0.174	-0.283	-0.449	-0.310	-0.192	1.00				
Final insect Population	-0.682	-0.072	-0.382	-0.159	-0.161	0.121	1.00			
% Damage	-0.690**	-0.99	-0.401	-0.105	-0.153	0.048	0.975**	1.00		
%Weight loss	-0.752**	-0.049	-0.398	-0.117	-0.236	0.016	0.958**	0.981	1.00	
Weight of Grain dust	-0.438	-0.142	-0.481	-0.200	-0.151	0.279	0.782**	0.740**	0.701**	1.00

** Correlation significant at 0.01 level (2 –tailed)
* Correlation significant at 0.05 level (2 –tailed)