Field Infestation and Development of *Sitophilus zeamais* (Coleoptera: Curculionidae) on Four Maize Cultivars in Nigeria

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Abstract

Infestation level of Sitophilus zeamais on four open pollinated maize cultivars namely; DMR ESR- Y, SUWAN – Y, TZE COMP 3 – W and TZPB SR-W (susceptible) was investigated in replicated field trials at the Teaching and Research Farm, University of Ibadan during two cropping seasons of year, 2013 and 2014. A 33.5 m x 6.5 m land area was divided into four blocks of four plots each. The four maize varieties were allocated randomly to each block in a randomized complete block design with four replications. Also, the developmental duration of S. zeamais on the maize cultivars was determined under laboratory conditions. Data obtained revealed that adult S. zeamais was first noticed on the field at 18th week after sowing. Higher abundance of S. zeamais was obtained in the susceptible TZPB SR–W maize variety than others in the two cropping seasons. Significantly higher number of egg-plugs (10.25; 8.25) were detected on TZPB – SR - W variety in the two cropping seasons while the least were found on SUWAN – Y (2.00) and DMR ESR – Y (4.75) varieties in the 2013 and 2014 cropping seasons respectively. Four larval instars, pre-pupa, and teneral adult were identified in the sampled grains of the maize cultivars. Developmental duration of S. zeamais was longest (35.6 days) on DMR ESR – Y and shortest (30.0 days) on TZPB SR – W. Cultivar DMR ESR-Y was the least preferred host to S. zeamais and could be included in developing an integrated management package for the pest.

Keywords: Abundance, Developmental duration, Egg-plugs, Infestation level, Maize cultivars

Introduction

Maize (*Zea mays* L.), is an important cereal crop in Nigeria where it serves as a major component of diet. It serves as a dietary carbohydrate for humans and livestock (Onwueme and Sinha, 1999; Asawalam and Hassanali, 2006). Tongjura *et al.,* (2010) stressed that maize provides families with much needed nutrients such as carbohydrates, proteins, fats, vitamin B and minerals. The major constraints to maize production in the tropics and subtropics is the attack by *Sitophiluszeamais* (Akob and Ewete 2007).

The maize weevil, *Sitophilus zeamais* Motschulsky is one of the most serious cosmopolitan pests of stored cereal grains, especially maize. It is known to infest maize in the field with infestation level increasing during storage (Haines, 1991; Adedire 2001; Lale, 2002; Babarinde and Kolawole, 2011). Declining food production, worsened by huge losses resulting from *S. zeamais* attack during maize storage expose farmers to different magnitudes of food shocks (Nwosu and Nwosu, 2012). Most research to date has centred on control of the maize weevils after harvest (Adane *et al.,* 1996; Obeng-Ofori and Amiteye 2005; Babarinde *et al*., 2008a, b; Akinbuluma and Ewete 2014; Akinbuluma *et al*., 2015). Other authors have assessed the susceptibility of some maize varieties to *S. zeamais* in the laboratory (Tongjura *et al.,* 2010). For instance, Nwosu *et al*., (2015) reported that certain physical characteristics as well as chemical composition of grains are linked to resistance and the susceptible nature of some maize genotypes.

However, there is limited information on field infestation by *S. zeamais* as well as describing its life history over a range of maize varieties. An understanding of the life history of the maize weevil in relation to different maize varieties will assist in the development of improved management practices for the control of this pest. The objective of the present study was to examine the field infestation levels and life history of *S. zeamais* on four maize varieties.

Materials and Methods

Study locations and experimental conditions

Laboratory experiment was conducted at the Entomology Research Laboratory, Department of Crop Protection and Environmental Biology, University of Ibadan under ambient temperature of 27 ± 2 °C, and relative humidity of 65 ± 5% while field trials were conducted at the Teaching and Research Farms, University of Ibadan between March and August in the years 2013 and 2014. Ibadan belongs to the rainforest /savannah transition zone and the Teaching and Research Farm lies on latitude 07°27'15.5"N and longitude 003°53' 31.1"E on the equator with an elevation of 194 metres. The experimental sites were cleared of bushes after two years of natural fallow, ploughed and harrowed.

Insect culture

Fresh culture of adult *S. zeamais* was established in the laboratory from an initial culture sourced from Bodija market, Ibadan. One hundred weevils (1male : 1female) were introduced into 250 g maize grains (TZPB SR –W variety) in each of eight 1-litre Kilner jars with mesh and arranged on a table whose stands were dipped in plastic bowls containing industrial oil to prevent ants from contaminating the cultures. After two weeks of mating and oviposition, the weevils were removed and the Kilner jars were observed daily with teneral adults removed from the cultures and sexed using the rostrum as the character for sex differentiation (Akob and Ewete, 2010). Culture was maintained as source of weevils for the laboratory experiments.

Source of maize cultivars

Clean and healthy seeds of four Open-pollinated maize varieties (TZPB SR-W; TZE COMP 3- W; DMR ESR - Y and SUWAN - Y) from the Institute of Agricultural Research and Training (IAR & T), Moor Plantation, Ibadan were used for the studies. Prior to the experiments, the grains were stored in a deep freezer (-20 °C) for three weeks to kill any insects resulting from field infestation and later air-dried in the laboratory to prevent mouldiness (Adedire and Lajide, 1999) and later removed for moisture equilibration for one week before use.

Field infestation of maize by *Sitophilus zeamais*

The experiments were conducted between March and August 2013 and 2014. A 33.5 m x 6.5 m land area, at the Teaching and Research Farm, University of Ibadan, was cleared, tilled, mapped out and divided into four blocks of four plots each. There was a 1.0 m guard row separating each of the plots and a footpath of 1.0 m surrounding the blocks. The four maize varieties were allocated randomly to each block in a randomized complete block design (RCBD) in four replications. Maize grains were sown at a spacing of 75 cm x 25 cm between and within the rows. Each plot size was 3.00 m x 1.75 m and sowing was done with three seeds per hole, and the seedlings thinned to one plant per hole at 3 WAS. Sowing of cultivar TZPB SR – W was done two weeks earlier than other maize cultivars. Weeding was carried out manually using hoes three times before harvest. Weekly observation for weevil infestation on maize cobs commenced at 14 weeks after sowing (WAS) for seven weeks and was carried out on the five middle rows on each plot. Data on the abundance of *S. zeamais* across the maize cultivars were collected at 16 - 20 WAS.

Laboratory assessments of egg-plugs of *Sitophilus zeamais*

Four ears/plot were harvested weekly beginning from 17 WAS, for three weeks, for laboratory assessment of weevil infestations. Harvested ears were de-husked, shelled and 400 grains from each maize cultivar were bulked in four separate jars. The jars were arranged in a completely randomized design and replicated four times. Assessment of egg laid by female *S. zeamais* on the grains was done using the acid fuchsin stain method (Frankenfeld, 1948), modified by Pederson (1979). The number of egg-plugs detected in harvested grains was estimated.

Development of *Sitophilus zeamais* on four maize varieties

Grains (100 g) from each of the four maize varieties was weighed and kept separately in four 1 - litre Kilner jars. Fifty 1-2 day-old adult maize weevil (1male: 1female) were introduced into four seperate jars. The experiment was arranged in a Completely Randomised Design with four replications. The weevils were left to mate and oviposit on the grains for seven days. Thereafter, 10 g of grains from each of the four maize varieties were removed and number of eggs laid determined using the egg-plug staining/ detection technique described above.

In order to study the developmental stages of *Sitophilus zeamais*, a destructive sampling method, which involved daily dissection of infested kernel was adopted. Dissection of kernels was carried out in a Petri dish using a razor blade and a scalpel and started 1 day after the termination of the egg-laying period and continued every day thereafter. Ten sampled kernels from each replicate from each variety were dissected on each occasion. Immature stages were carefully removed from the kernels with a fine camel hair brush and placed in separate Petri dishes. The stages of larval development were determined using the range of the head-capsule widths described by Sharifi and Mills (1971b) and the duration of stages was expressed in days, as measured from the beginning of the oviposition period until the time of each dissection. This was done till emergence of live adults. Teneral adult stage was taken as the stage when the adult has developed but still within the grain. Data on duration of different stages of development were collected.

Data analysis

Data on abundance of *Sitophilus zeamais* on the maize cultivars were analysed with descriptive statistics. The number of eggs laid and duration of development were analysed using analysis of variance (ANOVA) and means separated using the Least Significance Difference (LSD) at 5% level.

Results

Field infestation by *Sitophilus zeamais* on four maize cultivars

Abundance of *S. zeamais* on the grains of the maize cultivars between 16 - 20 weeks after sowing (WAS) during the 2013 and 2014 cropping seasons is presented in Figures 1a and 1b, respectively. There was no adult *S. zeamais* found on the maize varieties in the 16^{th} and 17^{th} weeks in both year. The number of weevils on TZPB SR-W ranged from 2 to 4 in 2013 and from 4 to 5 in 2014 in the 19^{th} and 20^{th} week, respectively. There was no insect was found on the DMR ESR – Y in 2013 and SUWAN –Y in 2014 (Figure 1a and 1b). Number of egg-plugs detected in the four maize cultivars harvested at 20 weeks of sowing is presented in Table 1. Significantly ($P < 0.05$) higher number of egg-plugs (10.25; 8.50) was detected on TZPB SR - W variety while lowest number of egg-plugs was found on SUWAN –Y (2.00) in 2013 and DMR ESR –Y (4.75) varieties in 2014 (Table 1).

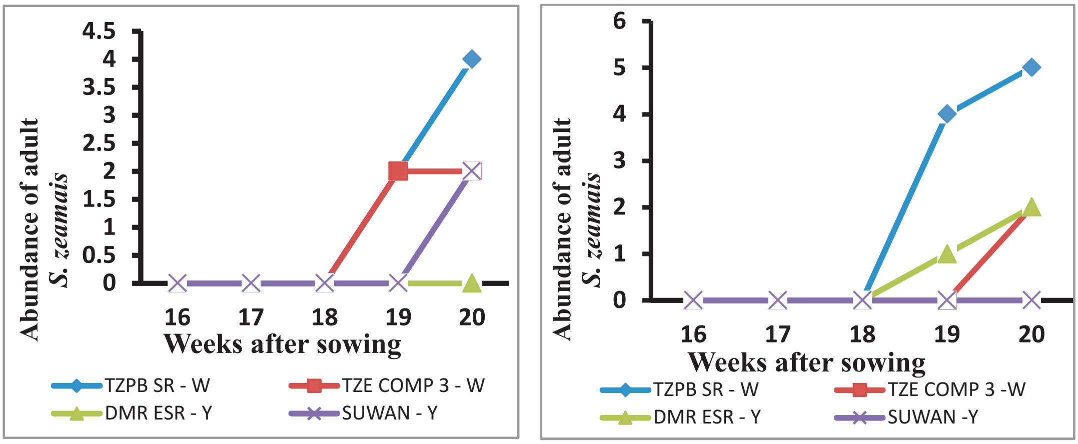

Figure 1: Abundance of adult *Sitophilus zeamais* on four maize cultivars at different week intervals in 2013 (a) and 2014 (b).

Table 1: Oviposition of *Sitophilus zeamais* grains of four maize varieties harvested from the Teaching and Research Farm, University of Ibadan, Nigeria

Maize cultivars	Egg-plugs (± S.D) in maize grains	
	2013	**2014**
DMR ESR – Y	3.25 ± 0.95	4.75 ± 0.85
SUWAN ESR – Y	2.00 ± 0.41	5.00 ± 0.82
TZE COMP 3 – W	5.25 ± 0.75	6.75 ± 0.25
TZPB SR – W	10.25 ± 1.65	8.50 ± 1.04
LSD $_{(0.05)}$	3.22	2.46

Development of *Sitophilus zeamais* on four maize cultivars

The mean number of eggs laid by *S. zeamais* was highest on cultivar TZPB SR – W (36.0) and lowest on cultivar DMR ESR – Y (30.0) (Table 2). However, there was no significant difference (P > 0.05) among the mean number of eggs laid on the four maize cultivars. Four larval instars, a pre-pupa, an exarate pupa and a pre-emerged adult stage were identified on the cultivars. With the exception of second and fourth larval instars, there were significant (P < 0.05) differences in the duration of development of various juvenile *S. zeamais* stages as well as in the teneral adult stage on the sampled maize cultivars.

Longer duration was required for the development of first and third larval instars, as well as pupation on the DMR ESR - Y and SUWAN – Y maize cultivats than in the TZE COMP 3 - W and TZPB SR - W varieties. Developmental duration was longest on cultivar DMR ESR - Y (35.6 days) and shortest on TZPB SR - W (30.0days). Duration on TZE COMP 3 - W and SUWAN – Y were not significantly different from susceptible TZPB SR – W (Table 2).

Discussion

In this study, there was no infestation by adult *Sitophilus zeamais* on the maize cultivars until the 18th week after sowing. Babarinde and Kolawole (2012) earlier observed that maize harvested late had higher infestation by maize weevil than the maize harvested early. They indicated that farmers could benefit by harvesting their crops early time to evade weevil infestation on the field. Such step of early harvest can reduce the tendency of build up to high weevil populations in the stored maize. Similar reports from Olubayo and Port (1997) indicated that cowpea seeds harvested at 4 weeks after recommended harvested time were infested by storage bruchids to a significantly greater level than those harvested at a recommended harvest time. In an evaluation of field susceptibility of maize to *S. zeamais* in Southwestern Nigeria, Makanjuola and Odebiyi (1987) reported that mean number of weevils found at harvest ranged from 0.75 to 15.5 on different maize varieties. Source of infestation in Makanjuola and Odebiyi (1987) is similar to what is obtained in the present study. Both farms were surrounded by old maize field with dry infested ears. Higher abundance of *S. zeamais* on the TZPB SR –W maize variety in the 2013 and 2014 cropping seasons may suggest that the maize variety was mostly preferred to others.

High number of egg-plugs detected in grains harvested from the Teaching and

Table 2: Mean number of eggs laid and developmental time (± S.D) of *Sitophilus zeamais* on four maize varieties ns = significantly different at 5 % level

Maize varieties	No. of eggs laid	Life stage duration (in days)						
		1st instar	2nd Instar	3rd instar	4th instar	Pre-pupa	Exarate pupa	Teneral adult
DMR ESR – Y	30.0 ± 3.37	11.5± 0.91	14.0 ± 1.58	16.0± 1.08	23.0 ± 1.81	25.0 ± 2.68	29.5± 0.71	35.6± 1.80
SUWAN ESR – Y	34.5 ± 4.20	12.0± 1.00	13.5± 0.42	16.5± 0.71	23.0 ± 1.58	26.5 ± 1.68	29.0± 0.71	33.0 ± 2.12
TZE COMP 3 – W	33.0 ± 4.55	9.50± 0.71	12.5 ± 1.00	15.0± 0.91	21.0 ± 2.68	24.5 ± 3.39	26.5± 1.78	31.5± 2.35
TZPB SR – W	36.0 ± 6.27	9.00±0.91	12.5± 0.71	14.5± 0.70	20.5± 3.00	22.3 ± 0.65	25.0± 0.71	30.0± 2.94
LSD $_{(0.05)}$	Ns	1.37	ns	1.57	ns	3.61	1.66	3.61

Research Farm, University of Ibadan, suggests infestation from the field which varied with maize cultivars. Studies on developmental period of *S. zeamais* on the different maize varieties in this study are similar to those of other reports. *Sitophilus zeamais* completed its development (egg – adult) on the grains of the four maize varieties. The development time ranged between 34.5 and 42.5 days on the four maize varieties. CABI (2010) reported developmental time range of about 35 days under optimal conditions to over 110 days in unfavourable conditions. Longer developmental time on cultivars DMR ESR - Y and SUWAN - Y than other two cultivars suggests that these cultivars are less preferred host to *S. zeamais*. Tongjura *et al*. (2010) reported notably high level of susceptibility of some maize cultivars including TZPB SR – W, to *S. zeamais*. In their study, significantly higher mean number of weevil was found on TZPB SR – W than in other varieties tested after six months of storage. Pupation of *S. zeamais* in the sampled maize cultivars in this study was between 25.0 and 29.5 days. This agrees with an earlier report by Odeyemi and Daramola (2000) who revealed that the pupation of *S. zeamais* occurred after about 25 days.

The level of field infestation by *S. zeamais* and its development on maize cultivars considered in this study can assist in the development of improved management practices for the control of this pest. Also, breeding programmes can combine the duration of development of the maize weevil in this study with selection for other characters such as grain hardness and protein content and consequently lead to the development of maize cultivars with enhanced resistance.

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