Evaluation of the resistance status of four varieties of maize to infestation and damage by *Sitophilus zeamais* (Motschulsky)

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Abstract

Two varieties of maize, TZMI205 and TZLCOMP4C3 have been found to be highly resistant, and two others TZECOMP3DTC2 and ACR97TZLCOMP4C2, susceptible to infestation and damage by Sitophilus zeamais Motschulsky, in previous studies. The resistance status of these four varieties was further evaluated in choice test under ambient laboratory conditions in Akure, Nigeria. The ability of ethanol extracts of the putatively resistant varieties confer resistance on the susceptible varieties was also investigated. TZMI205 suffered significantly lower damage than TZECOMP3DTC2 when grains of both varieties were simultaneously presented so S. zeamais. TZLCOMP4C3 was similar in susceptibility to ACR97TZLCOMP4C2 when grains of both varieties were also simultaneously presented to the weevil. Ethanol extracts of TZMI205 and TZLCOMP4C3 did not confer any significant level of resistance on grain of the susceptible varieties treated with them. The significance of these findings in the use of resistant varieties in S. zeamais control is discussed.

Key word: *Sitophilus zeamais*, resistant varieties of maize, susceptible variety of maize, ethanol extracts

Introduction

Maize, *Zea mays* L. also known as corn is one of the few staple crop grown in Sub-Saharan African and also an important grain crop of the world. It is a major component of the diet or an important food to the people of Sub-Saharan Africa (Ogunbodede and Olajoko, 1999). Maize is attacked by a wide range of pests world wide, more than 200 species of insects been recorded damaging the plant. The major constraint to utilization of maize in the tropics and sub tropics if the attack by the maize weevil *Sitophilus zeamais* Motschulsky. *Sitophilus zeamais* is one of the most serious cosmopolitan pest of stored cereals grain especially maize (Throne, 1994). Adult weevils and larva feed on undamaged grain and reduced them to powdery form. The infestation by maize weevil may commence from the field just before harvest and the weevil continues to reproduce and destroy the grains in the store. The larva develops and pupates within the grain, and the adult emerge through characteristic circular holes made on the grains. Damage to maize grain cause loss in weight, poor marketability, quality deterioration and low vitality (Agboola, 1982; Ivbijaro et al., 1985; Lale, 1992 and Enobakhare and Law-ogbomo, 2002). *S. zeamais* infestation during storage can be controlled by treating the grains with chemicals such as spraying with Pirimiphos-methyl or admixture with Pirimiphos-methyl dust so as to minimize weevil infestations. It can be readily controlled by fumigation with aluminum phosphide followed by storage in insect-proof containers (Adedire, 2001).

However, control of insects with chemicals insecticides has serious disadvantages such as the development of resistant strains, toxic residue, workers safety and increasing cost. Researches has been conducted on grain treatment with many plant products such as wood ash, plant oils and plant powders which have been found to be effective in controlling *S. zeamais* infestation (Lale, 1995). Formulation of these plants products and their adoption for large scale storage have not been adequately addressed (Ofuya, 2003). Varietal differences in the susceptibility of maize to infestation and damage by *S. zeamais* have been observed (Kossou et al., 1993; Gudrup et al., 2001; Enoakhare and Law-ogbomo, 2002). However, even the most promising traditional as well as newly developed varieties succumb to the storage pest after a period of time (Dobie, 1986). Nevertheless, the combination of low susceptibility in maize varieties in conjunction with other control measures may form an integrated pest management program which would provide a long lasting system to maintain insect population in stored maize in the Tropics at an acceptable low level (Gudrups et al., 2001). Arogundade (2005) assessed twenty varieties of maize for their susceptibility to post-harvest infestation by *S. zeamais*. It was revealed that maize varieties TZMI205, ACR91SUWAN-SRW and TZLCOMP4C3 appear to exhibit low susceptibility to infestation and damage by *S. zeamais*. The susceptibility was not related to seed hardness, size or weight. Balogun (2006) further investigated for susceptibility/resistance of these maize varieties to the pest and found that TZMI205 and TZLCOMP4C3 appear to exhibit very high resistance to infestation and damage by *S. zeamias* and concluded that low phytic acid content may be associated with resistance of maize grain to *S. zeamais*. In this present study a re-assessment of the resistance status of two most promising resistant and two susceptible varieties was carried out.

Materials and methods

This study was carried out in the research laboratory of the Department of Crop, Soil and Pest Management of the Federal University of Technology, Akure, under ambient laboratory condition of 28 ± 4°C and relative humidity between 65 ± 10%. The four varieties of maize used for this experiment were collected from the International Institute of Tropical Agriculture (IITA) Ibadan. The varieties were TZMI205 and TZLCOMP4C3 which were resistant to weevil attack and TZECOMP3DTC2 and ACR97TZLCOMP4C2 which were susceptible to weevil attack.

Insect culture

Adult maize weevil, *Sitophilus zeamais* were obtained from infested maize in Teaching and Research Farm of the Federal University of Technology, Akure. Insect culture was established on a clean susceptible maize variety. The weevils were introduced into the jar containing this maize variety and they were allowed to oviposit for a period of 10 days after which they were sieves from the medium and discarded. Thereafter, the grains were returned to the culture jar and left undisturbed until the weevil emerged at about 30 days after infestation.

Choice- test involving susceptible and resistant varieties

In the choice test the resistant maize varieties TZMI205 and TZLCOMP4C3 and susceptible maize varieties TZECOMP3DTC2 and ACR97TZLCOMP4C2 were used. 20 seeds of each of the susceptible maize variety were combined with 20 seeds of the resistant varieties of the maize grain in a Petri dishes, therefore making a total of 40 seeds per Petri dish. Since the maize seed used are the same and in order to differentiate the resistant seeds from the susceptible ones, the resistant seeds were marked with a marker at the helium area for identification in some trials while on other trials the susceptible seeds were also marked at the helium for identification. Thus giving a combination of the following:

TZMI205 with TZECOMP3DTC2
TZLCOMP4C3 with ACR97TZLCOMP4C2

Each combination of seeds was placed inside a Petri-dish and was infested with 20 pairs of newly emerged male and female *Sitophilus zeamais* adults (10 males and 10 females) and this was replicated 4 times. Two weeks after grain infestation, the introduced adults were removed and maize grain separated according to variety in different Petri-dishes and kept in the laboratory undisturbed until emergence of the F_1 generation. The newly emerged weevils were counted and the total number of the emerged F_1 progeny, number of holes on maize kernels and weight of emerged *S. zeamais* were recorded after five weeks.

Effects of surface extract of resistant variety on susceptible varieties

Alcoholic extracts of known resistant maize varieties TZMI205 and TZLCOMP4C3 were applied to susceptible maize varieties TZECOMP3DTC2 and ACR97TZLCOMP4C2. The extraction was carried out by soaking 20g of the resistant variety in alcohol for 24hrs. The extract was applied to 20g each of the susceptible variety at a concentration of 0.1ml per 20g of maize seed. 20 pair of adult *S.zeamais* (10 male and 10 females) were introduced into each Petri-dish containing 20g of each of the susceptible variety in four replicates. The weevils were allowed to feed and oviposit for a period of two weeks. After two weeks, adult mortality was recorded. Thereafter, all the weevils were sieved out. All Petri-dish were kept in the laboratory under ambient temperature and humidity until emergence of the F_1 generation. Five weeks after infestation data were recorded for the total number of adult weevil emergence, number of holes in the maize kernels and weight of adult *S.zeamais* that emerged.

Statistical analysis

Data collected from the choice-test was subjected to student T-test while all other data were subjected to the analysis of variance (ANOVA). Duncan Multiple Range Test (DMRT) was used to separate significant difference between treatment means.

Results

Adult emergence from resistant and susceptible maize varieties paired in choice tests is summarized in table 1. There was significant difference (P<0.05) in the means of the maize varieties with respect to the number of adult *S. zeamais* emerging after infestation. In TZMI205 the number of F_1 adult emergence recorded was significantly lower than in the susceptible variety, TZECOMP3DTC2 paired with it. There was no significant difference (P>0.05) in the number of F1 adult emergence in pairing involving TZLCOMP4C3 and ACR97TZLCOMP4C2.

Number of holes created in the maize varieties was significantly lower in TZMI205 (resistant variety) than in the other member of the pair TZECOMP3DTC2 (susceptible variety). Table 2, no significant difference (P>0.05) was observed in other paired varieties TZLCOMP4C3 and ACR97TZLCOMP4C2, with respect to holing of the grains.

Adult weight of *S.zeamais* emerging from paired maize varieties is shown in table 3. There was no (P>0.05) significant difference observed in the mean weight of the paired maize variety. Infestation and damage by *S. zeamais* in susceptible maize varieties treated with ethanol extract from resistant varieties (Table 4) observed as percentage mortality after two weeks of infestation in which there was no significant difference (P>0.05) between maize varieties treated with ethanol extracts from resistant varieties and their controls. Likewise, no significant difference was observed in the means of Adult emergence of *S. zeamais*, number of holes on maize varieties and adult weight of *S. zeamais* treated with ethanol extracts of resistant varieties and their controls which were treated with ethanol alone.

Table 1: Adult emergence of *Sitophilus zeamais* from Resistant and Susceptible maize varieties paired in choice-test

Paired varieties	Mean number of Adults emerged	T-test
TZMI205 (resistant)	3.2	
Versus		< 0.05
TZECOMP3DTC2 (susceptible)	4.9	
TZLCOMP4C3 (resistant)	3.0	
Versus		> 0.05
ACR97TZLCOMP4C2 (susceptible)	3.2	

Table 2: Number of holes for exit of *Sitophilus zeamais* in resistant and susceptible maize varieties paired in choice test.

Paired varieties	Mean number of Adults Emerged	T-test
TZMI205 (resistant) versus TZECOMP3DTC2 (susceptible)	3.2 5.3	< 0.05
TZLCOMP4C3 (resistant) versus ACR97TZLCOMP4C2 (susceptible)	3.0 3.5	> 0.05

Table 3: Adult weight (g) of *Sitophilus zeamais* emerging from resistant and susceptible varieties

Paired varieties	Mean number of Adults Emerged	T-test
TZMI205 (resistant) Versus TZECOMP3DTC2 (susceptible)	0.0030 0.0032	> 0.05
TZLCOMP4C2 (resistant) Versus ACR97TZLCOMP4C2 (susceptible)	0.0033 0.0032	>0.05

Table 4: *Sitophilus zeamais* infestation and damage in susceptible varieties treated with ethanol extracts from resistant varieties

Treatment	Mean % mortality of adults in 2 weeks	Mean adult emergence	Mean number of holes	Mean adult weight
TZLCOMP3DTC2 (treated with ethanol extracts from TZMI205)	22.65b	5.35a	6.09a	0.0034a
Control 1 (ACR97TZLCOMP4C2 Treated with ethanol only)	42.69a	3.63ab	3.70ab	0.0036a
Control 2 (TZECOMP3DTC2 (treated with ethanol only)	30.64b	5.22a	5.70ab	0.0034a
ACR97TZLCOMP4C2 (treated With ethanol extract from TZLCOMP4C3)	45.00a	2.90b	3.10b	0.0035a

Means bearing the same letters are not significantly different at 5% level of probability by Duncan's Multiple Range Test.

Discussion

Results from this study shows that the resistance to damage by *S. zeamais* exhibited by the maize variety TZMI205 is significant in comparison with three others assessed. This confirm observation by Arogundade (2005) and Balogun (2006). However, near immunity to *S. zeamais* attack as observed by these authors did not hold because moderate adult emergence was recorded from TZLMI205 in this study. But the adult emergence was significantly lower in TZMI205 as compared to other maize varieties. This showed that TZMI205 does indeed exhibit some level of resistance to *S. zeamais* but certainly far from complete immunity. The results of this study show that it is important to test resistance varieties over time show the durability of their resistance.

Dobie (1986) had also observed that even the most promising traditional as well as newly developed maize varieties succumb to *S. zeamais* after a period of time in storage. The phenomenon has been observed in other grains. For instance, resistant cowpea varieties have been demonstrated to suffer more damage with beetles of successive generation of *Callosobruchus maculatus* (Fabricus) (Adeduntan and Ofuya, 1998)

Chemical characteristics of the seed coat have been implicated in the resistance of selected varieties of cowpea to the storage beetle C. maculatus (Lale and Makoshi, 2000). However, in this study, ethanol extracts of the testa of grains from TZMI205 could not confer appreciable resistance on the susceptible variety treated with it. This may mean that the resistance of TZMI205 to *S.zeamais* is not due to surface acting chemicals in the testa or the solvent ethanol could not extract the chemicals. This means closer investigation.

Arogundade (2005) observed that physical characteristics of maize kernel such as grain hardness and weight were not responsible for resistance of TZMI205 and other maize varieties to *S. zeamais* attack. Resistance in shelled stored maize to *S. zeamais* attack has been attributed to a number of factors including starchy amylase content (Dobie, 1973) and other chemical compound found in the endosperm (Fortier and Anarson, 1982; Hossain et al., 2007). Balogun 2006 also observed that tannin content of grain was not responsible for resistance of TZMI205 and that low phytic acid content of grain might be associated with its resistance to *S. zeamais*. It is often considered that resistance of maize to stored product insect pest is multifaceted, with a number of factors contributing to the overall level of resistance observed (Dobie, 1977; Oigiangbe and Onolemhemhen, 1992; Hossain et al., 2007).

Therefore a more detail investigation of biochemical bases for the resistance TZMI205 should be carried out.

Conclusion and Recommendation

From the results of this study, the maize variety TZMI305 is not immune to damage by *S. zeamais* but it shows some level of resistance against the maize weevil *S. zeamais*, therefore, TZMI205 should be introduced in breeding programmes to incorporate the gene for its resistance to *S. zeamais* into susceptible varieties. Surface acting chemicals may not be responsible for the resistance of TZMI205 to weevil damage, for this reason a biochemical studies should be carried out to unravel the bases for resistance of the maize variety to *S. zeamais*.

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