Journal of Animal & Plant Sciences, 2011. Vol. 11, Issue 3: 1466-1473
Publication date: 31/10/2011, http://www.biosciences.elewa.org/JAPS; ***ISSN 2071 - 7024***

Resistance status of some maize lines and varieties to the maize weevil, S*itophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae)

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Key words: *Sitophilus zeamais,* Maize varieties, index of susceptibility, resistance

1 SUMMARY

This study was conducted to determine the resistance status of maize lines and varieties to *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) attack.

Ten maize lines; EVDTW99STRQPMCo, FU2090DYFP, TZEEY-PopSTRC4, DMLSRYQPM, GH90DYFP, FU2080DWF/DPop, TZE-Y-PopDTSTRC4, 2000SYNEEWQPM, GH90DWOP and Fu2090DWDPop, and three varieties; Dorke SR, Dodzi and Mamaba (flint maize) were subjected to *Sitophilus zeamais* attack in a completely randomized design set up. Ten females of *S. zeamais* were introduced into 50 grammes of shelled whole maize of each of the ten lines and three varieties to oviposit for three days. Based on knowledge of the life cycle of the pest, the set ups were checked for new emergences after 21 days. Emerged weevils were removed and counted daily without replacement, with the first batch of emergence occurring at 27 days after treatment from Fu2090DYFP and Fu2090DWDPop and the longest period of emergence observed in EVDTW99STRQPMCo, Dodzi, Dorke and GH90DWDP. The mean numbers of emerged weevils from the maize lines and varieties were significantly different (at P≤ 0.05). lines and varieties exhibited varying degrees of susceptibility and weight loss to the weevil attack, with line 2000S8NEEWQPMCo producing the least mean number of weevils, while line FU2090DYFP recorded the highest number. Based on their susceptibility indices, two lines and one variety are categorized as resistant and eight lines and two varieties as moderately resistant. The two lines (EVDTW99STRQPMCo and GH90DYFP) are therefore recommended to be included into the maize release programme. Maize lines FU2090DYFP, DMLSRYQPM, FU2080DWF/DPop, TZE-Y-PopDTSTRC4, GH90DWOP, Fu2090DWDPop, TZEEY-PopSTRC4, 20008YNEEWQPMCo and the varieties Mamaba and Dorke SR are also recommended to be included in breeding programmes to improve their resistance to *S. zeamais* for future release.

2 INTRODUCTION

Maize is an important subsistence and cash crop. After wheat and rice, maize is the third most grown cereal (Lyon, 2000). It occupies less land area than wheat or rice and has a greater average yield per unit area of about 5.5 tonnes per hectare (Ofori *et al.,* 2004). It is, however, attacked by insect pests prior to harvest and in storage (Caswel, 1962; Muyinza, 1998 and Demissie et al., 2008). The pests include the maize weevil, *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae), which could be the most predominant and destructive (Peng and Morallo-Releisus, 1987). The maize weevil is an important pest especially, on maize stored at the field for both food and seed (Thanda and Kevin, 2003) and can cause weight loss of stored grain from 20 to 90% for untreated maize (Adams, 1976; Mutiro et al., 1992; Derera et al., 1999; Pingali and Pindey, 2001). Post harvest losses due to *S. zeamais* are very important in the tropics (Markham et. al., 1994). Synthetic chemicals are easily and commonly used as control measures by most farmers to reduce storage losses caused by insect pests (Niber, 1994; Cherry et.al., 2005). However, some of the challenges associated with insecticide application includes toxic residues in food, environmental pollution, adverse effects on beneficial and non-target insects, increased risk to worker's safety, insect developing resistance against insecticides (Pereira et. al., 2009) and the high cost of the chemicals (Niber, 1994; Obeng-Ofori et.al., 1998; Asawalam et al., 2006) which render them less attractive for the management of these insects pest, either on the field or storage. Unfortunately, earlier maize breeding programmes had been concerned with increased yield, field pests and disease resistance. Since varieties were rarely assessed for resistance to stored product pests, the introduction of improved varieties had in the past, often been accompanied by reports of increased susceptibility to stored product pests (Fortier and Amason, 1982; Koussou et. al., 1992, 1993). It was therefore important to develop cheap and effective methods of reducing *S. zeamais* in storage maize such as the breeding of resistant varieties in most areas were the maize weevil is reported to be of economic importance with limited resources (Danho et *a*l., 2002). The objective of this study was to determine the level of resistance of some maize lines and varieties under the maize improvement project of the Crops Research Institute (CRI), Kumasi (Ghana) to *Sitophilus zeamais* attack.

3 MATERIALS AND METHODS

3.1 Maize lines and varieties*:* Ten maize lines (EVDTW99STRQPMCo, FU2090DYFP, TZEEY-PopSTRC4, DMLSRYQPM, GH90DYFP, FU2080DWF/DPop, TZE-Y-PopDTSTRC4, 2000SYNEEW QPM, GH90DWOP, Fu2090DWDPop) and three maize varieties (DORKE SR, Dodzi, Mamaba (flint maize) were used for the experiment. The materials were obtained from the Maize Breeding Section of the Council for Scientific and Industrial Research (CSIR) - Crops Research Institute (CRI) in Kumasi. They were sun dried for three days and placed in a deep freezer at -10˚C for two weeks to kill any existing/hidden storage pests. They were further air-dried in an oven at 30˚C for 7 days to a moisture content level of 12 $\pm$ 2 %. The moisture content level was measured at the Entomology laboratory of the Kwame Nkrumah University of Science and Technology (KNUST) with a moisture tester (Model 8400-121, serial no 9906-11702, 1728 Mapiavian Drive, Troy Michigan 48084. SIEBE) obtained from the Seed Unit of the Maize Section of CSIR - CRI.

3.2 Sitophilus zeamais culture: A culture of *S. zeamais* was obtained from the insectary of the Entomology unit of the Department of Crops and Soil Sciences of KNUST. Three hundred adult weevils of varying ages (150 males and 150 females) were introduced into one-litre Kilner jar with 500 g of Obatanpa maize and replicated three times. The insects were allowed to oviposit for seven days after which they were retrieved by sieving with a mesh size of 2mm. The Kilner jars were covered with wire netting lined with muslin material to prevent possible escape or re-infestation. The F_1 adults that emerged were introduced into other Kilner jars containing Obatanpa maize and the resulting F_2 adult weevils which emerged between 0-10 days were sieved and used to infest the experimental maize stock at 68- 70% average relative humidity and temperature of 28-30˚C.

3.3 Experimental set up: Fifty grammes of maize was taken from each line or variety and put into 500 ml plastic containers. Each container was infested with 10 males and 10 females of 0-10 day-old *S. zeamais* adults from the laboratory stock and replicated four times in a Complete Randomised Design. Three days after infestation, weevils were sieved out of the maize. After setup the maize samples were left for the weevil to complete a cycle of development and were then sieved daily for adult weevil count until no weevil emerged. Data collected included total number of weevils that emerged 63 and 96 days after setup, number of maize grains with exit holes and calculation of the percentage weight loss of grains of each of the setups, as per the FAO (1985) method as follows:

% Weight loss = [UaN-(U+D)] / UaN x 100.

Where: N= total number of grains in the sample

U= weight of undamaged fraction in the sample,

Ua = average weight of one undamaged grain,

D= weight of damaged fraction in the sample.

Dobie's (1974) index of susceptibility was also used to determine susceptibility of the grains attacked by *S. zeamais* as follows:

Index of susceptibility = 100 x $\log_e$ F/D, where F= total number of F_1 progeny emerged

D= median development period

The median development period was calculated as the time (in days) from the middle of the oviposition period to the emergence of 50% of the F_1 progeny. The susceptibility index, ranging from 0 to 11, was used to classify the maize varieties; in which 0-3 was considered as resistant, 4-7 as moderately resistant, 8-10 as susceptible, and11 and above as highly susceptible.

3.4 Statistical Analysis: Data obtained were subjected to statistical analysis of variance using PROC GLM; SAS Institute (2004) (version 9). Where significant,,, means were separated with Student Newman Keul's (SNK) Test. Insect counts were log-transformed prior to analysis (Sokal and Rohf, 1981). Mortalities were adjusted using Abbott (1925) and their percentages were arcsine transformed.

4 RESULTS

There were significant differences in the emergence of the adult maize weevil among the various treatments (P= 0.0004). The first batch of weevils emerged 27 days after setup (DAS) and was from lines DMLSRY, GH90DYFP, Fu2090DWDPop, 2000S8YNEEWQPMCo, FU2090DYFP and Mamaba variety. Delayed emergence was observed in EVDTW99STRQPMCo and GH90DWDP lines and Dodzi and Dorke SR varieties, starting at 30 days after setup (Figure 1). (Distinguish between lines and varieties). The least number of weevils emerged from line 2000S8YNEEWQPMCo and the largest from line FU2090DYFP (Figure 2). The least and the highest mean losses in weight were recorded in lines 2000S8YNEEWQPMCo, with a value of 0.1% and FU2090DYFP, with a value of 4.7%, respectively (Figure 3). Using Dobie's index of susceptibility, line 2000 S NEEW QPM recorded the highest index, while line EV DTW99STRQPMCo had the lowest (Table 1). Dodzi variety and GH90DYFP line could be classified as resistant while eight lines and two varieties were moderately resistant (Table 1). There were significant differences among weight loss of the various maize lines and varieties (P=0.0001) with the least occurring in the variety Dodzi and the largest loss in the lines TZEEY-Pop STR C4 and GH90DWDP (Figure 4), after 102 days of weevil infestation

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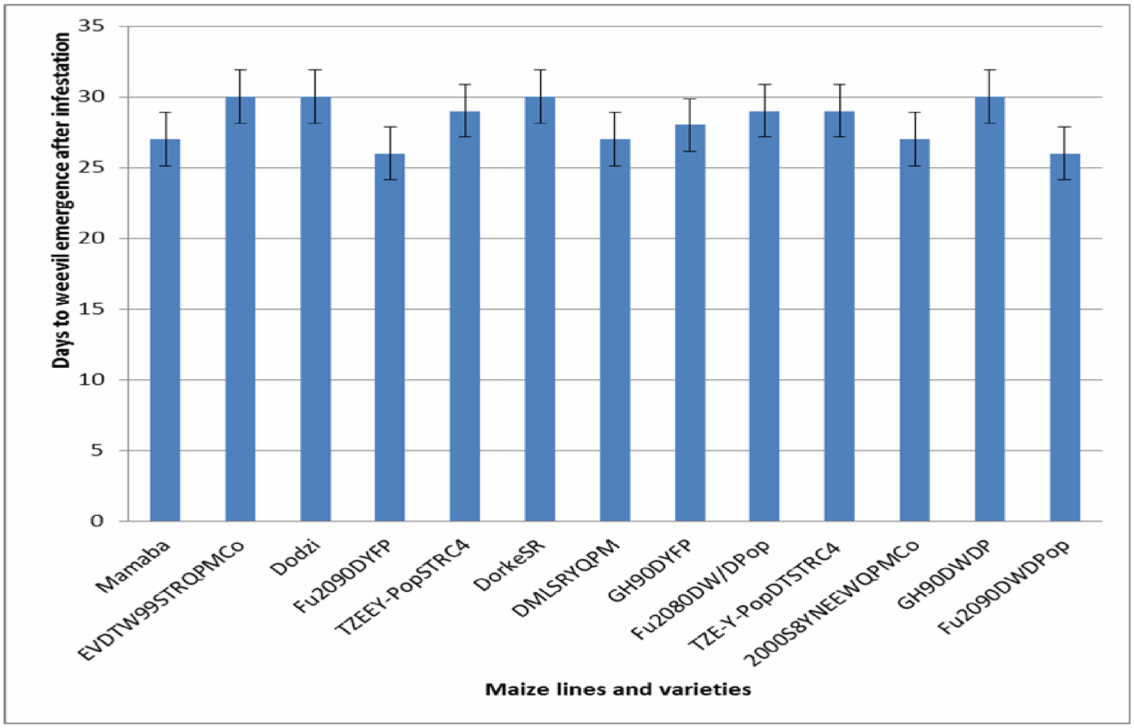

Figure 1: Days to weevil emergence from ten lines and three maize varieties after setup from infestation with ten weevil couples

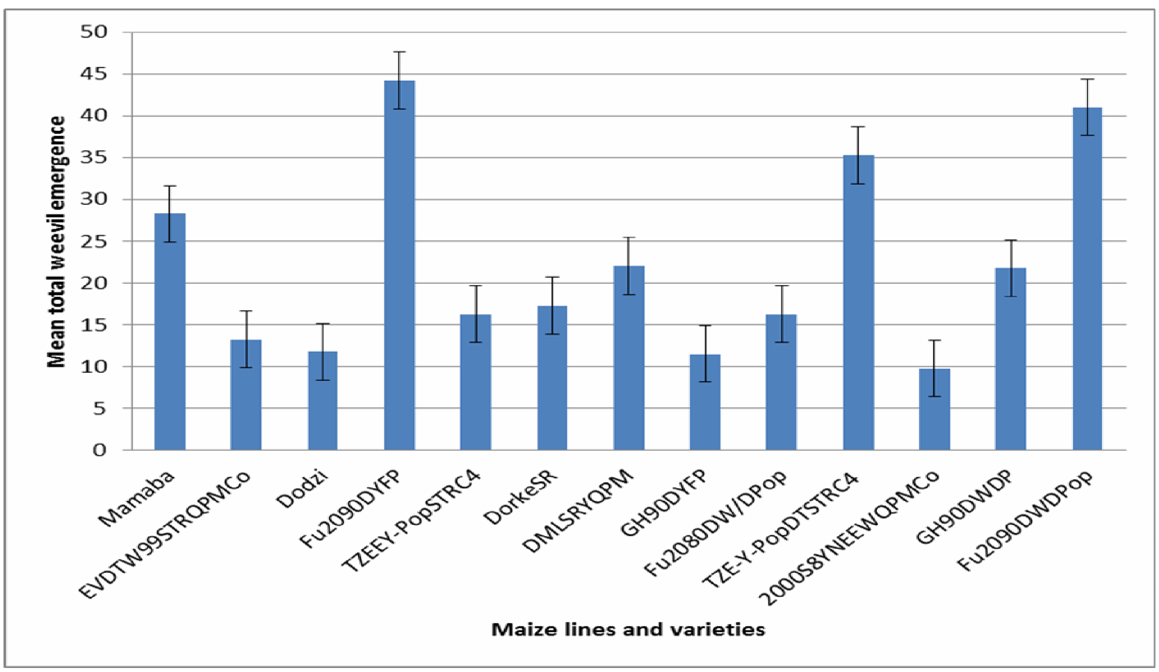

Figure 2: Mean total emergence of *S. zeamais* from ten lines and three maize varieties at sixty three days after setup from infestation with ten couples.

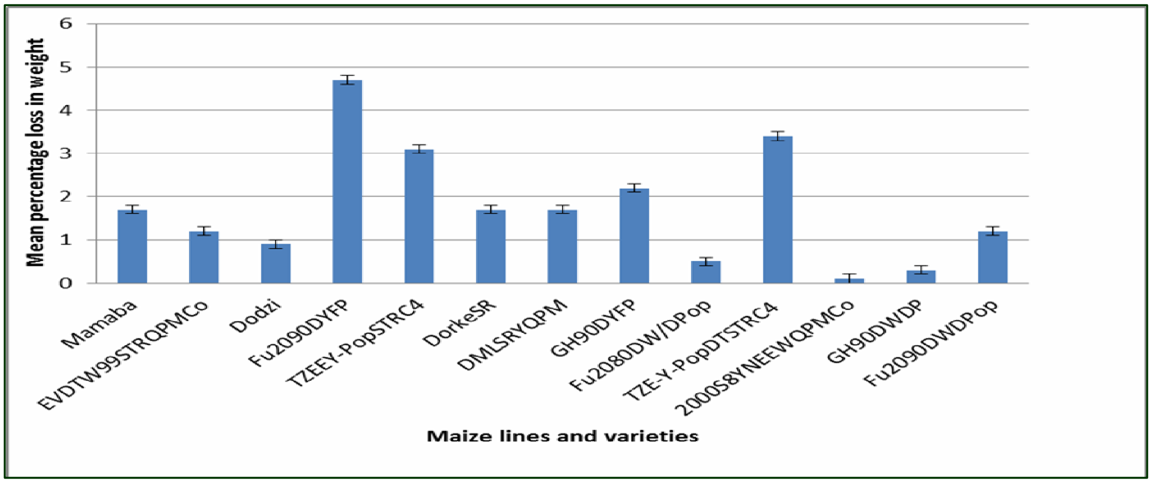

Figure3: Mean percentage loss in weight from ten lines and three maize varieties at sixty three days after setup from infestation with ten couples.

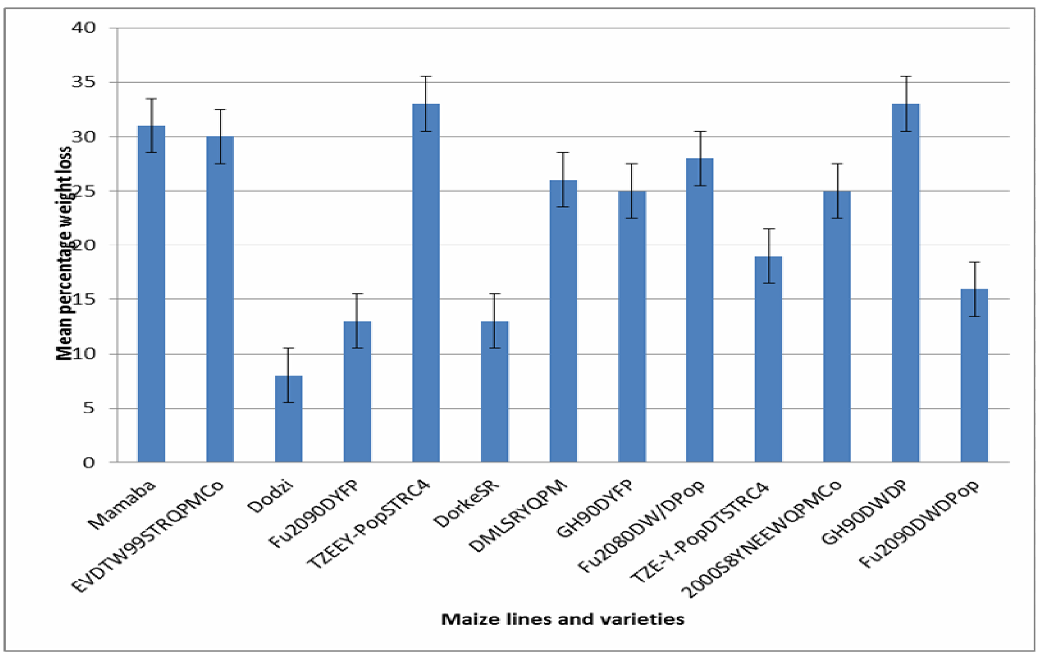

Figure 4: Total number of *S. zeamais* from ten lines and three maize varieties at ninety sixty days after setup from infestation with ten couples.

Table 1: Susceptibility of ten lines and three varieties of maize to *S. zeamais* attack

Varieties/Lines	Total emergence	Median Dev't Period	Index of susceptibility	Susceptibility status
Mamaba*	13.3	34.3	3.9	Moderately resistant
Dodzi*	11	34.5	3.3	Resistant
Dorke SR*	16.8	31	3.9	Moderately resistant
EVDTW99STRQPMCo	17	33	3.2	Resistant
FU2090DYFP	57.5	42	4.3	Moderately resistant
TZEEY-PopSTRC4	33.5	37.8	3.5	Moderately resistant
DMLSRYQPM	24.5	31.5	4.3	Moderately resistant

GH90DYFP	10	29.5	3.3	Resistant
FU 2080 DWF/DPop	11.5	31.8	3.6	Moderately resistant
TZE-Y-PopDTSTR C4	47.3	37.8	4.0	Moderately resistant
2000S8YNEEWPMCo	8.8	22.8	5.0	Moderately resistant
GH90DWDP	22.8	31.5	4.3	Moderately resistant
FU2090 DWDPop	17	31	4.6	Moderately resistant

* =Variety and no star = line in Table.

The varieties and lines were rated from the scale above, where varieties and lines below 3 were considered as resistant and the varieties and lines with values between 4 and 7 as moderately resistant.

5 DISCUSSIONS

Results from this study show that all the lines and varieties exhibited some resistance to *S. zeamais* attack. GH90DYFP and EVDTW99STRQPMCo lines and Dodzi variety exhibited more resistance and can be stored with lesser maize weevil damage comparatively. The emergence of adult *S. zeamais* showed that some of the lines, particularly Fu2090DYFP andFu2090DWDPop, could be described as suitable resource for the development of the maize weevil. This is in line with earlier work by Derera et al. (1998) who stated that the development of an insect was influenced by the nature of food the insect was reared on and that generally, more eggs were laid and developed faster on a more favourable than a less favourable host. Similar trends were also shown by Dobie (1974) that, shape, size, grain hardness, chemical and nutritional composition were important primarily in resisting insect attack and damage. Within the first two months of storage, none of the lines and varieties showed any significant damage or weight loss. Even though the weevil populations might have been low, there was some grain damage which was similar to the work of Arthur (1992), who reported that maize weevils caused kennel damage in test bioassays even when populations were extremely low. Beyond two months of storage, there were increases in weevil numbers, leading to increased losses in grain weight. Some other studies however showed that, resistance alone was not enough to suppress *S. zeamais* population build up and damage, but rather could complement and contribute to integrated pest management (Gudrups et al., 2001; Credland et al., 2005). Similarly, Ivbiljaro (2009) stated that resistant maize cultivars can reduce losses due to weevil infestation but no maize grain was immuned to attack by the weevil. In conclusion, there was little or no information on resistance of the test maize lines and no update on resistance of the varieties to the maize weevil. Earlier maize breeding work was more focused on improving yields at the expense of insect protection, resulting in the breeding of some varieties which were susceptible to maize weevil attack (Mario et al., 2009). Derera et al. (1999) and Pedigo (2002) mentioned similar trends in their work that maize breeding until recently, emphasised on yield at the expense of nutrition and insect resistance. Therefore, parent stock of maize lines such as TZEEY-PopSTRC4, FU2090DYFP, DMLSRYQPM, FU2080DWF/DPop, TZE-Y-PopDTSTRC4, GH90DWOP, Fu2090DWDPop and 20008YNEEWQPMCo found to be moderately resistant to *S. zeamais* attack, could be used by breeders in their breeding programmes.

6 ACKNOWLEDGEMENT

This study was sponsored by Strengthening of Agricultural Research in Developing Countries (SCARDA) programme in conjunction with CSIR-Crop Research Institute (CRI). Dr B. Amoako Atta, retired entomologist of the Faculty of Natural Resourses and Dr Osekre E.A. of KNUST provided valuable suggestions.

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