Scientific Research and Essay Vol. 5 (1), pp. 030-034, 4 January, 2010
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 © 2010 Academic Journals

Full Length Research Paper

The susceptibility of different maize varieties to post-harvest infestation by *Sitophilus zeamais* (MOTSCH) (Coleoptera: Cuculionidae)

N. Makate

Department of Biological Sciences, University of Botswana, Private Bag UB 00704
Gaborone, Botswana. E-mail: makaten@mopipi.ub.bw. Tel: +0267 355 2589. Fax: +0267 3554465.

Accepted 29 June, 2007

Nine maize varieties collected at IITA were investigated for their relative susceptibilities to attack by *Sitophilus zeamais* MOTSCH, an important insect pest of stored maize. The results obtained were summarized using an index of susceptibility which took into account both the F_1 progeny developing during the tests and a measure of the average development period of this progeny. The varieties arranged in a descending order of susceptibility were EV-8431-SR, 8321-18, IK85T2 SR-W, DMR-LSR-W, 8516-12, 8644-31, EK 83T2-SR-Y, 8425-8Y and 8505-5. There was a positive correlation between the susceptibility index and certain grain characteristics or factors such as moisture content, imbibitions potential and weight per 1000 seeds.

Key words: *Sitophilus zeamais*, maize susceptibility, insect infestation.

INTRODUCTION

Maize (*Zea mays*) probably originated as a cultivated plant in Central America several thousand years before the arrival of Europeans in the African continent (Dobie, 1977). Thereafter it has been introduced to many more ecological zones all over the world. At present maize is cultivated in high altitude regions like the Andes and Himalayas, temperate regions and hot humid tropical plains.

Maize is regarded as one of the staple food in the Southern and Middle zones of Nigeria. It is the third most widely cultivated cereal crop in the country after guinea corn and millet. Up until about the last twenty years, maize was mainly grown by the peasant farmers under the traditional mixed cropping system. The increased demand for the commodity as raw material for the brewing, poultry and livestock industries as well as other agro allied and confectionary industries in recent times have resulted in large scale production of the commodity under the mechanized monoculture farming system.

According to the 1975 FAO (Production Year Book) estimates, cited by Adesuyi and Shode (1977), Nigeria produced about 8.061 million tons of grains, out of which 1 million tons was maize. One of the major causes of low maize production is insect pest attack in both field and store. The report estimates a world-wide annual loss of 10% in stored grains but in the tropical countries of Africa, Taylor (1977) observed that these losses vary from 30 - 50% *Sitophilus* species are the major post-harvest pests of maize, guinea corn, rice and wheat. Usually their infestation starts in the field some weeks before harvest and the population builds up in stores or cribs (Cornes, 1964). Damage is done by both the adult larva as they feed on the endosperm of the grain and create exit holes. Taylor (1977) estimated that one larva can consume about 7% of the weight of maize grains.

Adesuyi and Shode (1977) reported that 24.7% of the maize stored in traditional storage structures is lost after six months of storage and *Sitophilus zeamais* is largely responsible for this. In the field, the degree of infestation is mainly determined by the completeness of the husk covering the cob (Giles and Ashman, 1971). Maize may be stored either on the cob (unthreshed) or after removal from the cob (threshed). In store, the number of *S. zeamais* present at any time will depend upon the initial population of the insect at harvest; the numbers of insects subsequently infesting the crop from elsewhere, and the rate of multiplication of the insects within the crop (Dobie, 1974). The rate of multiplication of the insect depends upon the temperature and moisture content of the maize.

Development from egg to pupa is within the grain. The female creates cavities in the maize kernel, inserts the small white eggs into them and seals them with a gluey substance called the egg plug. The egg plugs can be detected by staining the grains with acid fuschin as they are invisible under normal observation. After pupation, the adult emerge from the grains through an exit hole. Depending on the temperature and relative humidity of the environment, the whole development cycle takes 4 – 16 weeks (Jones and Jones, 1974). The number of the eggs laid the viability of these eggs and the time taken for the adult to emerge may all vary in samples of different maize varieties (Dobie, 1974).

An integral part of maize improvement programmes has been the search for varieties that are resistant to insect pests attack. This interest is being pursued actively through breeding in many national and international institutes. Along this line, varieties resistant to stored product pests infestation are preferred.

This project was aimed at assessing the susceptibility of some maize varieties bred at the International Institute for Tropical Agriculture (IITA) Ibadan, to *S. zeamais* under storage; with the hope that the results obtained will help in deciding which of the varieties should or should not be released to farmers for cultivation.

MATERIALS AND METHODS

Maize varieties

The nine varieties used were collected from the International Institute of Tropical Agriculture (IITA), Ibadan. These were: IK85T2SRW, DMR-LSR-W, EV-8431-SR, 8321-18, 8505-5, 8644-31, 84-25-8-Y, ek83tsr-y and 8516-12.

Test for susceptibility

Fifty grams of each variety was weighed into 100 ml beakers, covered with muslin cloth and arranged in a Gallenkamp incubator plus series No. 3 and kept at room temperature (25°C) for three days to attain stable environmental conditions. Thereafter twelve females and six males of *S. zeamais* aged between 0 and 7 days from a culture maintained in the laboratory were introduced into each beaker containing the conditioned maize. The insects were left in the beakers for 7 days and were checked for adult mortality. Dead ones were removed and replaced with ones from the culture. This set was meant to condition the insects to the maize varieties.

Four days into this period, another set of 50 g of each variety was weighed into 100 ml beakers and covered with muslin cloth as for the first set. At the end of the 7^{th} day for the first set, insects conditioned to the three replicates of a particular variety in the first set were transferred to the three replicates of the same variety in the second set. The second set had at this time spent three days in the incubator and the grains were conditioned.

The first set of maize was then discarded and the insects were allowed to lay eggs in the second set for another 7 days. However during this period, dead ones were not replaced. At the end of the 7 days, the insects were removed and discarded. The entire set up was then left in the incubator undisturbed, until the first adults of the F_1 generation emerged. These were removed and counted at frequent interval usually daily, for the following four weeks (after oviposition) as recommended by Wheatley (1973) and Morah and Mbata (1982). The total number of F_1 adults and the time from oviposition to the emergence of 50 percent of these adults was noted. The data was used to calculate the index of susceptibility as enunciated by Wheatley (1973) and Dobie (1974). Means of the F_1 progeny for the varieties were subjected to statistical analysis using the Duncan's multiple range test.

Characteristics of the varieties

Certain factors or characteristics which could be responsible for the susceptibility or relative resistance of each variety to *S. zeamais* were investigated; these were factors such as moisture content equilibrium, apparent weight loss, seed permeability to water and weight of seeds.

Moisture content equilibrium

About 20 g of each variety was ground in a Glen Creston hammer mill through a 1.00 mm sieve. The samples were then divided into three replicates of 5 g for each variety and dried in a fan ventilated hot box oven (Gallenkemp size 2) at 130°C for one hour. The samples were reweighed after drying and the percentage moisture content was determined.

Apparent weight loss

Fifty grams of grain for each variety was weighed before the introduction of the insects. At the end of the emergence of the F_1 progeny, the respective weights were again taken. The percentage difference was recorded as the apparent weight loss.

Permeability to water

Two hundred grains of each variety were selected and divided into two replicates of 100 grains each. The weight of each set of 100 grains was determined and the grains were placed in 100 ml beakers and steam-boiled in an autoclave for one hour ten minutes. Thereafter excess water on the grain surface was removed. The final weight was taken and the difference in weight was determined for each variety. The correlation coefficients between these characteristics and susceptibility index were calculated.

RESULTS AND DISCUSSION

Susceptibility of the varieties

Table 1 shows the physical characteristics, total number of F_1 progeny, period of emergence of 50% of this progeny, and the indices of susceptibility for the nine maize varieties. The results indicate a high degree of variation in the susceptibility index of the varieties with the most susceptible variety being 8505-5. This variety produced 5 times as many F_1 as variety EV-8431-Sk which is the least susceptible. This work shows that using the susceptibility index is as good as assessing maize resistance to *S. zeamais* by the degree of damage or weight loss.

The mean developmental period for 50% of F_1 progeny ranged between 33 - 35 days with a mean of 33 + 0.79. The mean temperature of the incubator during the trial

Table 1. The physical characteristics, total number of progeny, period of emergence of 50% of F_1 progeny and indices of susceptibility for the nine maize varieties.

Maize varieties	Physical characteristics of varieties	Total No. of F1 progeny	Time for emergence of 50% F1 progeny	Susptibility index
IK85T2 SR-W	White/Flint Dent	30 ab	34	10.00
DMR-LSR-W	White/Flint	29 ab	33	10.20
EV-8431-SR	Yellow/Dent	15 a	33	8.20
8321-18	White/Flint Dent	21 a	35	8.70
8505-5	White/Dent	77 c	34	12.77
8644-31	Yellow/Dent	51 abc	35	11.23
8425-8-Y	Yellow/Dent	61 bc	34	12.09
EK 83T2-SR-Y	Yellow/Flint	53 abc	33	12.03
8516-12	White/Dent	38 ab	33	11.02

Means followed by the same letters are not significantly different from each other.

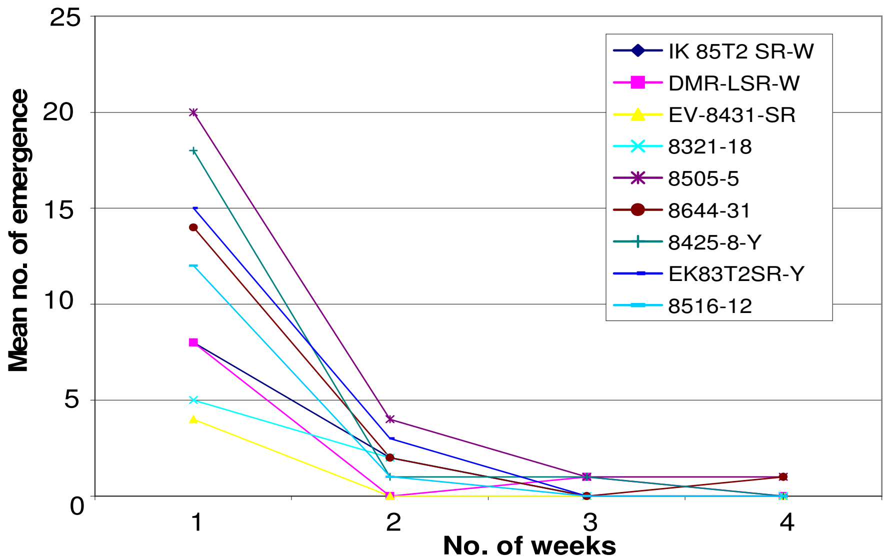

Figure 1. No. of F_1 emergence (progeny) per week for the different maize varieties.

period was 26 ± 2°C. For the least susceptible was 33 days. There was significant Wheatley (1973) while working with some local and difference between the developmental periods of the F_1 progeny for the nine varieties ($P < 0.05$).

For the most susceptible variety, the mean developmental period was 34 days while the difference in the developmental period of *S. zeamais* in the least most susceptible varieties. He also found a seven times increase in F_1 progeny of the most susceptible over the least susceptible. Dobie (1974) recorded 33.8 days as the developmental period for a highly susceptible maize variety and 36.5 days for a resistant variety. From these observations it would however appear that the inherent quality of the grain determines the developmental period.

The weekly pattern of emergence of F_1 progeny is shown in Figure 1, while Figure 2 shows the cumulative pattern of emergence. From Figure 1, it is clear that 70% of the insects emerged within the first week of initiation of emergence that is 31 - 37 days after ovipositor. It would appear, therefore, that the ease with which the adults feed on the grain may determine the rate of oviposition as feeding is an essential precussor to oviposition, and not the ability of the female to penetrate the kernel in order to lay eggs (Coombs and Porter, 1986).

Figure 2 shows that after 44 days of oviposition 85 - 100% of the F_1 progeny had emerged. Table 2 shows mean number of dead parent insects when introduced into the maize varieties. There was no significant difference between the values for each variety ($P < 0.05$). These findings confirm the observation of Dobie (1977) who observed that susceptible maize varieties were as attractive to adult *S. zeamais* as resistant ones. Thus the factors that determine resistance act mainly after

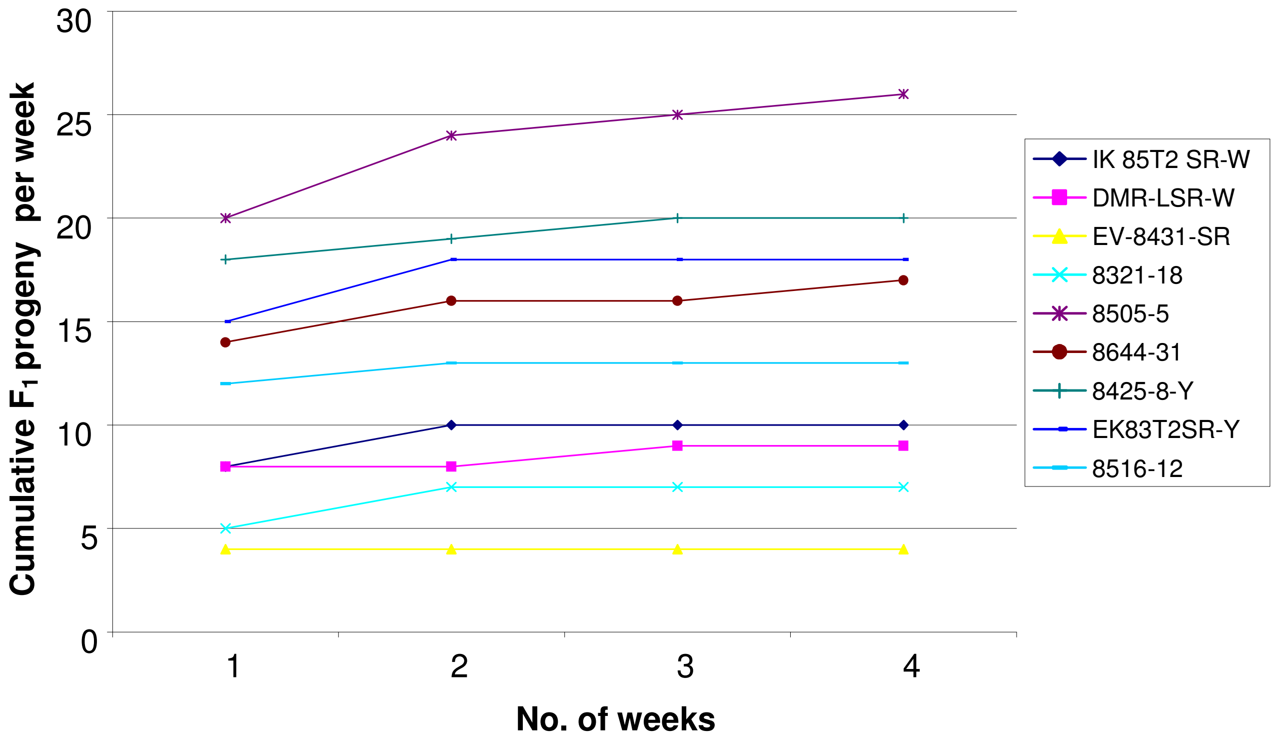

Figure 1. Total cumulative emergence of F_1 progeny per week for the different maize varieties.

Table 2. Mean number of dead parent insects found in the different maize varieties.

No. of weeks	Maize varieties								
	IK85T2 SR-W	DMR-LSR-W	EV-8431-SR	8321-18	8505-5	8644-31	8425-8-Y	EK83T2-SR-Y	8516-12
Week 1	1	5	5	9	2	6	2	2	5
Week 2	3	4	5	3	10	8	-	9	5
Week 3	2	2	6	3	5	2	2	3	3
Week 4	2	3	2	1	1	-	-	2	1
Total	8	14	18	16	18	16	4	16	14
Mean	2.0	3.5	4.5	4.0	4.5	4.0	1.0	4.0	3.5

Table 3. Grain characteristics: moisture content, weight loss, weight of 1,000 seeds and imbibition potential for maize varieties, and their correlation coefficients.

Maize varieties	Moisture content (%)	Weight loss (%)	Imbibition potential (%)	Mean wt. per 1,000 grains (g)
IK85T2 SR-W	11.60	4.86	60.72	260.45 bc
DMR-LSR-W	10.60	2.83	53.66	259.19 bc
EV8431-SR	10.20	3.94	46.62	255.96 b
8321-18	11.13	2.54	47.36	282.69 d
8505-5	11.65	5.86	48.94	276.06 cd
8644-31	11.37	3.68	50.12	220.03 a
8525-8-Y	9.41	4.43	52.99	248.22 b
EK 83T2 SR-Y	11.14	4.17	48.85	255.10 b
8516-12	10.20	3.77	50.84	257.39 bc
Correlation coefficients	0.15	0.56	0.37	0.21

Means followed by the same letters are not significantly different from each other.

oviposition.

Effects of some grain characteristic factors on susceptibility

Table 3 shows the relative values of certain grain coefficients. There was no significant difference between the values for moisture content, imbibition potential and weight per 1,000 seeds ($P < 0.05$) of the varieties. From the table, it is clear that all the namely, moisture content, weight of 1,000 seeds, weight loss and imbibition potential and their correlation factors show a positive correlation. That the values for moisture content and weight per 1,000 seeds were very low can be attributed to the fact that the varieties were dried to low moisture content for storage before they were used for this experiment.

Weight loss is well known and is used as a parameter for assessing susceptibility. The imbibition potential is a measure of the ease with which water can pass through the testa and be retained in the endosperm of the grain. From these results, there is a loose positive correlation between susceptibility and ability to imbibe water. It is however suggested that this is a fair method of assessing the degree of hardness of the grain.

Conclusion

That the maize weevil, *S. zeamais*, is a major post-harvest pest of maize cannot be over-emphasized. It is necessary for factors which influence susceptibility to be elucidated so as to provide information to maize breeders. This will enable them to combine a high degree of resistance with good grain quality. Obviously the potential yield of any variety is the most important consideration in deciding whether or not to grow it. The results of this experiment have shown that varieties EV-8431-SR and 8321-18 are highly resistant to *S. zeamais*. DMR-LSR-W, IK85T2-SR-W, 8516-12, are moderately susceptible.

It is hereby suggested that only the above highly resistant and moderately resistant varieties could be released to farmers for planting or cultivation purposes.

REFERENCES

Coombs CW, Porter JE (1986). Some factors affecting the infestation of wheat and maize by Sitophilus oryzae (L.) and Sitophilus zeamais MOTSCH (Coleoptera: Curculionidae). J. Stored Prod. Res. 22: 33-41.

Cornes MA (1964). An estimation of the value of the maize husk as protection against Sitophilus zeamais. Rep. Niger. Store Prod. Res. Inst. pp. 76-79.

Dobie P (1974). The laboratory assessment of the inherent susceptibility of maize varieties to post-harvest infestation by Sitophilus zeamais (MOTSCH) J. Stored Prod. Res. 10: 183-197.

Giles PH, Ashman F (1971). A study of pre-harvest infestation of maize by Sitophilus zeamais MOTSCH. (Coleoptera, Cuculionidae) in the Kenya highlands. J. Stored Prod. Res. 7: 69-83.

Jones F, Jones MG (1974). Pests of field crops. 2nd Ed. Edward Arnold, London P. 448.

Morah M (1982). Relative susceptibility of different maize varieties. Nigerian Stored Prod. Res. Inst. Ann. Report.

Taylor LR (1977). Damage caused by Sitophilus zeamais MOTSCH. In maize. J. Stored Prod.

Tipping PW (1987). Effects of whole corn kernels and extracts on behavior of maize weevil (Coleoptera: Curculionidae). J. Econ. Entomol. 80(5): 1010-1013.

Wheatley PE (1973). Relative susceptibility of maize varieties. Tropical Stored Prod. Information (30): 16-17.