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Resistance of Maize Varieties to the Tropical Warehouse Moth, *Ephestia Cautella* Walker (Lepidoptera: Pyralidae)

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Abstract: *Insect pests have continually hampered the production and utilization of maize. One of the ways of tackling their menace is through the introduction of resistant varieties. However, screening of maize varieties for resistance to moths has been under investigated. In this study, resistance of seven maize varieties to the tropical warehouse moth, Ephestia cautella (Walker), was evaluated in the laboratory at a temperature of 31±2°C and relative humidity of 78±3%. The tested maize varieties were LNPC4-4F2, ACR88Pop, ACR89DMR, DMRSR F1, TZL Comp1, TZBR Comp2 and K9350. Twenty grammes of each variety was infested with five pairs of adult E. cautella and replicated four times. The parameters used for the evaluation of resistance were grain damage, weight loss, adult emergence and calculated susceptibility index (SI). The most resistant of all the tested varieties with no grain damage, weight loss nor adult emergence was DMRSR F1. Hence, this variety had a zero susceptibility index. The most susceptible variety to E. cautella having the highest percentage grain damage (46.06%), weight loss (3.91%), adult emergence (21.66) and susceptibility index (SI = 3.82) was ACR89DMR. The remaining varieties had SI values ranging between 1.8 to3.59. Since the highest susceptibility index obtained was less than 5, all the tested varieties were relatively resistant to E. cautella infestation to various degrees. However, there was significant positive correlation at 0.05 levels between the grain length and the susceptibility of the varieties to E. cautella.*

Keywords: *Ephestia cautella, maize varieties, resistant, grain damage, susceptibility index.*

1. INTRODUCTION

Maize, *Zea mays* L., is an important cereal food globally. It has become predominant particularly in terms of the ecological zones covered in its production [1]. The importance of this crop in the economy of several nations cannot be over-emphasized. Though highly valuable, the activities of insect pests have been a menace on its production, storage and utilization; these pests include Coleopterans (such as *Sitophilus zeamais* Motsch. and *Rhyzopertha dominica* F.) and Lepidopterans (such as *Ephestia cautella* Walker and *Plodia interpunctella* Hubner) [2].

The tropical warehouse moth, *E. cautella* (or *Cadra cautella*), is a serious pest of a wide range of commodities including cereals and cereal products, cocoa, oilseed etc. It is found throughout the tropics and subtropics; but it can develop during summer in temperate countries and throughout the year in food industry environments with high temperatures [3]. Its larvae which are the destructive stage are found as primary pests infesting whole grains and feeding on the germ. Pupation occurs in small aggregations of grains held together with webbing [4]. Under optimum conditions (32.5° C and 70% r.h.), its development from egg to adult takes approximately 29-31 days and the estimated rate of increase is about 50 times per lunar month [3]. The webbing and the frass produced by this pest affects the aesthetics and handling process of infested produce.

The trend of post harvest pest control is drifting away from the use of conventional insecticides due to their numerous shortcomings [5]. The breeding of grain varieties resistant to post harvest pest is one of the alternative control measures being explored [6]. Various researchers have screened several maize varieties for their resistance to the notorious Coleopterous pest of maize, *Sitophilus zeamais* Motsch. [1], [7], [8], [9], [10] & [11]. On the contrary, there is limited information on maize varietal screening for resistance to moths. In the light of the above facts, this study screened seven maize varieties for their susceptibility to *E. cautella*.

2. MATERIALS AND METHODS

2.1. Insect Culture

The initial stock culture of *Ephestia cautella* used for this study was obtained from infested cocoa beans collected from a cocoa industry in Akure, Nigeria. New generations from the initial stock were reared in the laboratory on clean uninfested, susceptible local yellow maize variety in Kilner jars covered with muslin cloth. This is to allow adequate aeration and prevent moth escape. The culture was maintained at an ambient temperature of 31±2^{o}C and 78±3 % relative humidity.

2.2. Maize Varieties

Seven maize varieties were collected from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The susceptibility or resistance of these varieties to *E. cautella* infestation was evaluated at the Department of Biology, Federal University of Technology Akure, Nigeria. The seven varieties were LNPC4-4F2, ACR88Pop, ACR89DMR, DMRSR F1, TZL Comp1, TZBR Comp2 and K9350. The morphological characteristics of these varieties are shown on Table 1. The moisture content of all the varieties was determined using Mettler LJ16 Moisture Analyzer.

2.3. Assessment Method

Twenty grammes of grains from of each variety were weighed into separate 250ml plastic jars. Five pairs of newly emerged *E. cautella* (male/female) adults were introduced to each jar and then covered with muslin cloth. This test had four replicates. The infested grains of each variety were left for oviposition and development of the immature stages. Adults died within 7 to 9 days.

After four weeks, the infested maize grains were inspected daily for adult moth emergence. The emerging F_1 generation adults were counted and removed daily to avoid generational overlap.

The total number of F_1 adults that emerged from each variety was counted. Likewise the time from oviposition set up to adult emergence were recorded for each jar. All experiments were carried out in the laboratory at ambient condition (31±2^{o}C and 78±3% relative humidity).

At the end of the experiment, the number of damaged grains was estimated by counting the perforated or partly chewed grains. Likewise, the final weight of each sample was measured and used to calculate the weight loss. The index of susceptibility of each variety was also determined according to Dobie's method [7]:

$$\text{Index of susceptibility (SI)} = \frac{\text{Natural Log F}}{D} \text{ x} \frac{100}{1}$$

Where F is the total number of emerged F_1 adult moth and D is the median developmental period in days (i.e. the time from the middle of oviposition period until the emergence of 50% of the F_1 generation).

The four parameters described above (adult emergence, grain damage, weight loss and susceptibility index) were used to assess the susceptibility of each maize variety to *E. cautella*.

2.4. Data Analysis

Data collected were subjected to analysis of variance (ANOVA) and where significant differences were found, the means were separated using the New Duncan's Multiple Range Test. Pearson's correlation analysis was also performed on the grain length and index of susceptibility at 0.01 and 0.05 levels using the SPSS (Statistical Package for Social Sciences) Version 10.0.

3. RESULTS

3.1. Adult Emergence

The number of adult *E. cautella* that emerged from the different maize varieties is shown on Table 2. The least number of adult emergences was recorded in variety DMRSR F1 from which no adult could emerge. Variety TZBR Comp2 recorded the second level of the least number of adult emergences (mean of 6.00 adults per jar). The highest adult emergence of 21.66 was recorded in variety ACR89DMR. The zero adult moth emergence from DMRSR F1 was significantly lower ($P < 0.05$) than emergence from the other varieties except variety TZBR Comp2. This result revealed that the

grains of maize variety DMRSR F1, was not a suitable host for *E. cautella* to develop and complete its life cycle.

3.2. Grain Damage

The percentage grain damaged by *E. cautella* was likewise highest (46.06%) in ACR89DMR as revealed in Figure 1. This was closely followed by the damages observed on ACR88Pop (45.98%) and K9350 (44.79%). The percentage damage recorded in these three varieties were significantly higher than those recorded in the other varieties. No grain damage was recorded in variety DMRSR F1 (0%).

3.3. Weight Loss

Figure 2 shows the percentage weight loss of the maize varieties with ACR89DMR having the highest value (3.91%) followed by K9350 (3.69%) and ACR88Pop (3.38%). The least

Table1.*Morphological characteristics of the investigated maize varieties*

Variety	Colour	Grain Length (mm)	% Moisture Content
LNPC4-4F2	Yellow	14	11.5
ACR88Pop	White	13	10.9
ACR89DMR	White	11	10.1
TZL Comp 1	White/Yellow	7	11.0
DMRSR F1	Yellow	6	11.7
TZBR Comp 2	White/Yellow	10	12.3

Table2. *Adult emergence (mean ± S.E) of Ephestia cautella from different maize varieties at 31±2 ^{o}C and 78±3% R.H.*

Variety	Adult emergence
LNPC4-4F2	12.33 ± 3.17bc
ACR88 Pop	18.00 ± 6.08c
ACR89 DMR	21.66 ± 1.85c
TZL Comp 1	13.00 ± 2.08bc
DMRSR F1	0.00 ± 0.00a
TZBR Comp 2	6.00 ± 4.50ab
K9350	16.33 ± 1.85c

Mean values in a column followed by the same letter are not significantly different (P ≥ 0.05) by New Duncan's Multiple Range Test

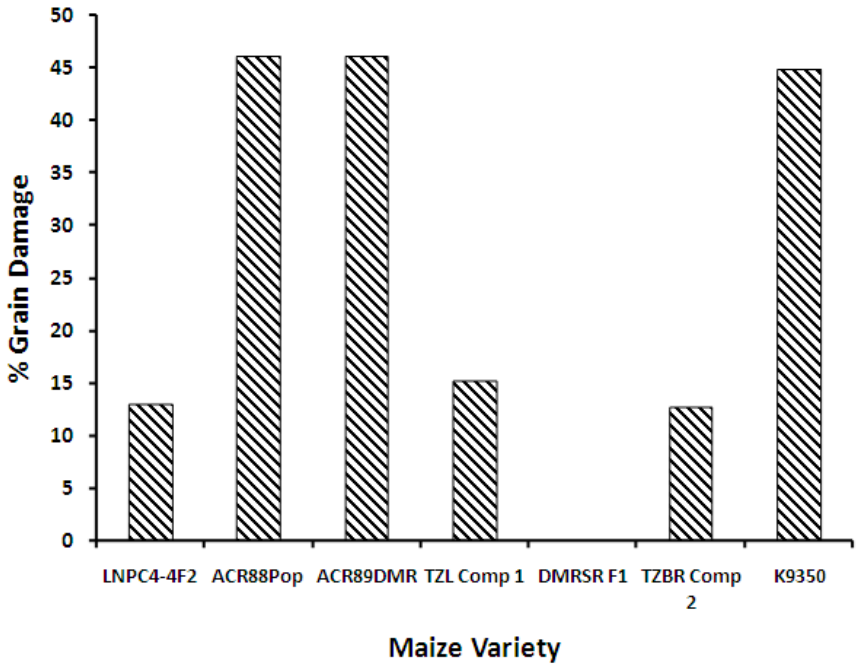

Figure1. *Percentage grain damage of maize varieties infested with E. cautella*

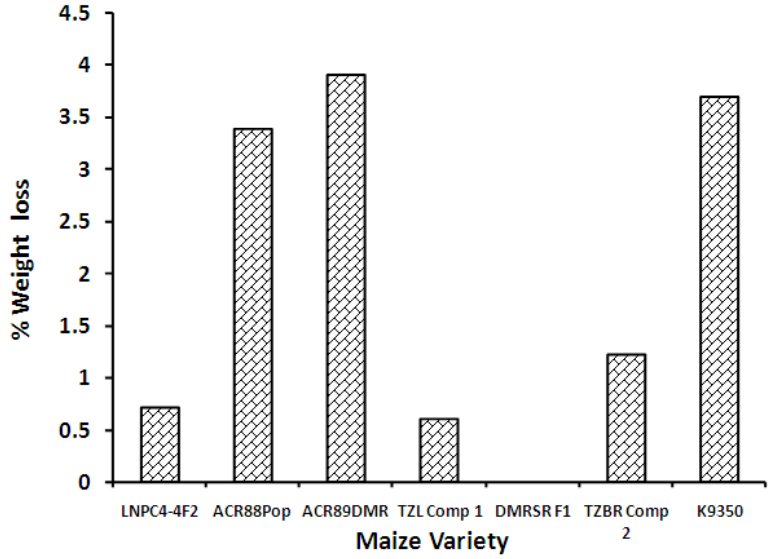

Figure 2. *Percentage weight loss of maize varieties infested with E. cautella*

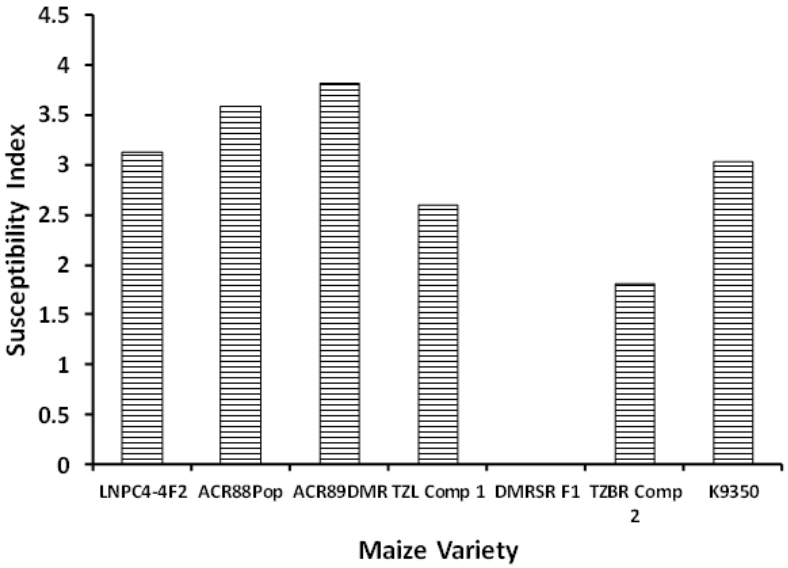

Figure3. *Susceptibility index of maize varieties to E. cautella*

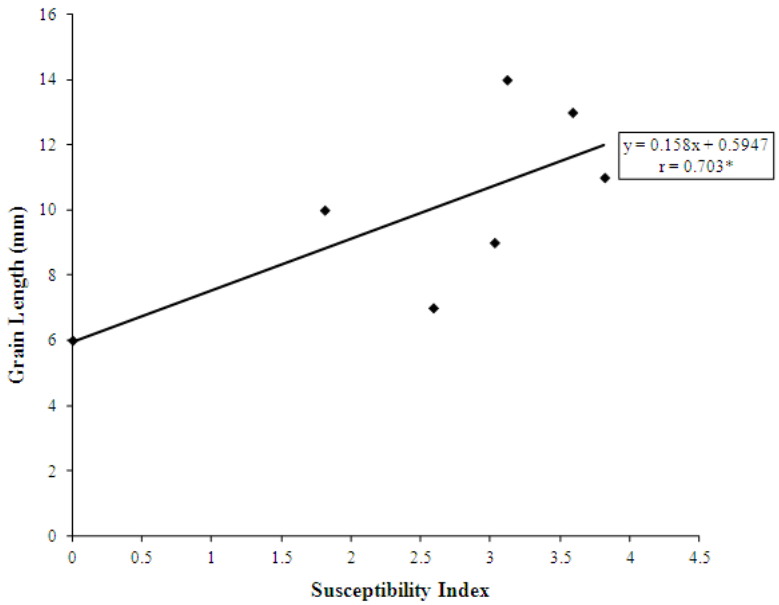

Figure 4. *Correlation between susceptibility index and grain length of maize infested by E cautella*

*Correlation is significant at 0.05 levels

Weight loss (0%) was observed in DMRSR F1, but analysis revealed that there was no significant difference (P>0.05) in the weight loss recorded in all the seven varieties investigated.

3.4. Susceptibility Index

The calculated Susceptibility index (SI) was highest in ACR89DMR with an SI of 3.82 (Figure 3) while the DMRSR F1 had the lowest (SI=0.00). This shows that ACR89DMR was the most susceptible of all the investigated varieties to *E. cautella* infestation while DMRSR F1 was the most resistant. Considering all the parameters used in this study (adult emergence, grain damage, weight loss and SI), ACR88Pop and K9350 also have close proximity to the susceptibility of ACR89DMR to *E. cautella* infestation. On the overall, there was a positive relationship (r = 0.703) between the grain length and the susceptibility of the varieties infested with *E. cautella,* though not significant at 0.05 level (Figure 4).

4. DISCUSSION

Several varietal resistance researchers on maize varieties have employed the parameters used in this study especially against coleopterans [7], [9], [10] & [12]. Ashamo and Khanna [13] used similar parameters to study the resistance of paddy varieties to the Angoumois grain moth, *Sitotroga cerealella* Olivier.

The numbers of adults of an insect species that emerge from a grain play an important role in determining the susceptibility or resistance of the grain variety toward such insect [14]. This study showed that variety DMRSR F1 from which no adult moth emerged had total resistance to *E. cautella*. This might be due to the inability of the first larvae instars of *E. cautella* to pierce or chew their way through the seed coat into the kernels [15]. Stored product moths lay their eggs on the surface of the seed coat leaving their larvae to find their way into the kernel. Unlike the moths, the curculionids, such as the maize weevil, *Sitophilus zeamais*, aid their first larvae instars to penetrate maize kernels by laying their eggs in cavity chewed into the grain by female adults. Ashamo [10] reported that maize grains with soft seed coat were more susceptible to *S. zeamais* infestation than seeds with hard seed coat, this might give an insight into the ability of variety DMRSR F1 to completely resist *E. cautella* attack.

Though not investigated in this study, the resistance status of DMRSR F1 and TZBR Comp2 to *E. cautella* might be connected with grain hardness. Adedire et al [14] observed that

maize variety BR928-DMRSRF_2 was the hardest out of 11 varieties studied for susceptibility to

Sitophilus zeamais. They likewise discovered that the aforementioned variety was among the 2 most resistant varieties to *S. zeamais* in their study. Hard grain might have limited the extent of the accessibility of the germ/endosperm of the grains to the larvae. This in turn will reduce or hamper the development of such larvae. Grain hardness has been generally implicated in the resistance of grain to insect infestation [10], [12] & [16]. Locatelli *et al* [17] reported a significant longer period for the hatching of the eggs of the rice moth, *Corcyra cephalonica* Stainton, to commence on a hard genotype of wheat than the soft one. Likewise the period of its development from egg to adult was significantly longer on the hard genotype than on the soft one.

Biochemical components of grain varieties are other characteristics known to be associated with the development of insects [18] & [19]. The emergence of lesser number of adult progenies from variety TZBR Comp2 reveals that its nutritional support for the development of *E. cautella* could be very low when compared to variety ACR89DMR. Ashamo and Khanna [13] reported that varieties of rice paddy with low amylose content tend to be more susceptible to infestation by the Angoumois grain moth, *Sitotroga cerealella*, than rice varieties with higher amylose content. The lower adult emergence from TZBR Comp2 could also be due to the presence of some alkaloids or amino acids in this variety [10], [15] & [20]. In a study carried out on the yam moth, *Dayses rugosella* Stainton, it was observed that the adult emergence (survival) was poorest from the "bitter or trifoliate yam", *Discorea dumetorum* Kunth (Pax) while the highest survival was from "water yam", *D. alata* [21]. The author inferred that this disparity was probably due to the presence of some bitter substances such as tannins, alkaloids (dihyrodioscorine) and steroidal sapogenins in *D. dumetorum*.

In this study, though there was variation in the percentage weight loss recorded but no significant difference was observed in the losses from the different maize varieties. Sharma and Bajracharya [12] also made the same observation on the percentage weight loss in different maize varieties infested with *Rhyzopertha dominica*. On the contrary, Ashamo [10] observed significant difference in the percentage weight loss of the different maize varieties infested with *S. zeamais*.

Considering the effect of size and grain length on the susceptibility of maize varieties to *E. cautella* infestation, the longest grain was not the most susceptible. But analysis revealed a significant positive correlation between grain length and susceptibility to *E. cautella* infestation. This is consistent with many previous works done on varietal resistance [13], [16] & [22]. This implies that there is the tendency of a maize variety to be susceptible to *E. cautella* infestation if it is long.

5. CONCLUSION

The indices of susceptibility of all the maize varieties investigated in this study were less than 5, therefore all of them are resistant to *E. cautella* infestation [10]; however, the most resistant was DMRSR F1 while the most susceptible or least resistant was ACR89DMR. Therefore cultivation and storage of resistant maize variety will help to reduce or prevent infestation by *E. cautella*. Nevertheless, this is dependent on the maize variety available in each locality, hence, farmers need to check for their local variety most resistant to this moth.

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