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MAIZE GENOTYPES AND RESISTANCE TO RICE WEEVIL, SITOPHILUS ORYZAE (COLEOPTERA: CURCULIONIDAE) AND ANGOUMOIS GRAIN MOTH, SITOTROGA CEREALELLA (LEPIDOPTERA: GELECHIDAE)

P. LAKSHMI SOUJANYA*, J.C. SEKHAR* AND P. KUMAR**

**Winter Nursery Centre, Directorate of Maize Research, Rajendranagar, Hyderabad 500030*
***Directorate of Maize Research, Pusa Campus, New Delhi -110 012*
E mail: soujanyak.scientist@gmail.com

ABSTRACT

Grains of eleven maize genotypes were evaluated for their resistance to rice weevil, *Sitophilus oryzae* (L.) and Angoumois grain moth, *Sitotroga cerealella* (Oliv.) by 'No choice' method under laboratory conditions (28±2°C and 60±5% RH). Adult emergence, seed damage, weight loss and susceptibility index were used as parameters. The results indicated that for *S. oryzae*, adult emergence seed damage and weight loss were low in Shaktiman1 (41, 12% and 0.29%) and RHM 2 (40, 17.00% and 0.73%), respectively. These data were higher in PEEHM 5 (228.00) followed by Shaktiman 2 (85.00). The genotypes when screened against *S.cerealella* showed highest adult emergence in VH 9 (63.00) followed by PEEHM 5 (58.50). Consequently the seed damage and weight loss were higher in PEEHM 5 (63.15, 14.27) and VH 9 (48.27, 10.13) while it was low in VH 4 (4.28, 2.74) followed by VH 5 (6.70, 2.86), respectively. The moderately susceptible genotypes were found to be Shaktiman 1 to *S. oryzae* while VH 4 and VH 5 to *S. cerealella*. However, none of the genotypes were found to be least susceptible to *S. oryzae* and *S. cerealella*. The correlations between adult emergence, seed damage, and weight loss and susceptibility index were significant and positive for both pests.

Key words: storage pests, *Sitophilus oryzae*, *Sitotroga cerealella*, resistance, grain damage, weight loss

Maize (*Zea mays* L.) is one of the most important cereal crops after rice and wheat with an area of 8.6 m ha with production of 20.5 mt and productivity of 2.4 t/ha. (Annual Report, 2011-12). During post harvest storage, grain is vulnerable to many insect pests. Among these, rice weevil, *Sitophilus oryzae* (L.) and Angoumois grain moth, *Sitotroga cerealella* (Oliv.) are most destructive, develop within grain kernels, causing considerable direct damage as well as making the grain more suitable medium for reproduction of secondary insect pests. High moisture content of grains (>12%), high atmospheric temperature (25 to 35°C) and relative humidity (>60%) during storage make the environment conducive for proliferation of storage pests. It is estimated that 5 – 10% of world's food grain production is lost due to ravages of insect pests. These losses increase to 50% due to improper storage conditions in hot and humid summer season (Maqsood *et al.*, 1988). World wide seed losses ranging from 20 to 90% have been reported due to the maize weevil *Sitophilus zeamais* (Giga *et al*., 1991). Infestation by these pests commences in the field but most damage occurs during storage. Insecticides are widely used to protect grain from infestations but their cost, availability, increasing occurrence of resistance and recent ban of methyl bromide, envisage developing alternative strategies. It is important to consider natural resistance in grain to control storage insect pests. Knowledge of grain resistance based on physico-chemical characteristics and insect behaviour would help in decreasing the post harvest storage losses. The use of resistant or least susceptible genotypes (Dobie, 1977) integrated with other sustainable pest control methods will provide a long lasting solution. Keeping these in view relative susceptibility studies were carried out to evaluate some genotypes against *S. oryzae* and *S. cerealella.*

MATERIALS AND METHODS

Screening against *S. oryzae*

Unsexed *S. oryzae* were collected from infested maize seed and cultured on clean and disinfested maize seed (DHM 117) in jars, each with 1.0 l capacity, containing 200 weevils per 500 g of seeds. The jars were covered with muslin cloth and fixed with rubber band to allow aeration and to prevent escape of weevils and were kept at room temperature. Seven days after oviposition, all parent weevils were removed from each jar and were placed on another set of seeds kept at the same conditions. This was repeated until sufficient numbers of laboratory reared weevils of known age were available. Freshly harvested seeds of procurred genotypes were, cleaned and disinfested keeping them in a deep freezer for two weeks prior to starting the experiments. The seeds were then kept for two weeks at the experimental conditions for acclimatization. The moisture content of the seeds was 12 - 13% as determined by U.S. Farmex moisture meter.

A total of eleven maize hybrids were screened by no choice test method, thirty newly emerged unsexed adult weevils were introduced to the jars to infest the 100 g seeds and kept for seven days for oviposition (Dobie, 1977; Derera *et al.*, 2001). The treatments were arranged in a completely randomized block design with three replications. After removing all the insects, the seeds were kept under the same experimental conditions to assess the adult emergence daily. Emerging progeny was removed and counted per jar on each day. These observations continued for 56 days until all progeny was expected to have emerged.

Sixty-three days after introduction of the weevils, 100 seeds were randomly taken from each jar. The number of seed damaged (holed seed) was assessed and expressed as %. Seed weight loss was determined using the count and weight method of Gwinner *et al.* (1996): Weight loss (%) = (Wu x Nd) - (Wd x Nu) X 100 / Wu x (Nd + Nu); Where Wu = Weight of undamaged seed; Nu = Number of undamaged seed, Wd = Weight of damaged seed; and Nd = Number of damaged seed.

The median development period was calculated as the time (days) from the middle of the oviposition period to the emergence of 50% of the progeny (Dobie, 1977). The index of susceptibility was calculated using the method of Dobie (1974) as follows:

Index of susceptibility = 100 x [loge (total number of F1 progeny emerged) / (median development time)]. The susceptibility index, ranging from 0 to 11, was used to classify the maize varieties; where; 0 - 3 = least susceptible, 4 - 7 = moderately susceptible, 8 - 10 = susceptible and >11 = highly susceptible.

Screening against *S. cerealella*

Samples of seeds were conditioned for two weeks before experimentation. Freshly laid eggs of S. *cerealella* were obtained from the laboratory culture of *S. cerealella* maintained on a maize hybrid (DHM 117) at 28±2°C and 65±5% R.H. The eggs were counted with the help of a stereoscopic microscope and papers carrying 50 eggs each were placed in each 50 g sample of seeds placed in glass jars covered at the top with a muslin cloth. The experiment was designed in three replications with a control allotted to each variety. All the samples placed with eggs were maintained at 28±2°C and 65±5% R.H. The data on adult emergence, grain damage and weight loss were determined. Per cent damage and weight loss were calculated by using the formulae:

% Damage= weight of control sample- weight of sound grain sample / weight of control sample x 100

% Grain weight loss = weight of control sample- weight of (sound + damaged) grain /Weight of control sample x 100

The data recorded were transformed before subjected to analysis of variance and significant means were compared using Duncan's multiple range test at 5% level of significance.

RESULTS AND DISCUSSION

The results revealed that Shaktiman1 (12.00) recorded lowest damage due to *S.oryzae* followed by RHM 2 (17.00) and PEEHM 2 (17.50) while it was highest in PEEHM 5 (48.50) followed by RHM 1 (33.50) and VH 9 (33.00) (Table 1). The percent weight loss was significantly lower in Shaktiman1 (0.29) followed by RHM 2 (0.73) and VH 4 (0.90) while it was significantly higher in PEEHM 5 (2.76), RHM 1 (2.70) and VH 9 (2.54). Similarly the mean F1 progeny ranked from 10 for genotype Shaktiman1 to 228 for genotype PEEHM 5. The development period ranged from 38.00 days for VH 5 and VH 9 to 43.00 days for Shaktiman1 (Fig.1). *S. oryzae* reared on Shaktiman1 had relatively higher development period. Varieties with high adult emergence tended to have shorter development period. The index of susceptibility ranged from 3.92 in Shaktiman1 and 13.78 in VH 9 (Fig.2.) The higher the index the more susceptible is the genotype. Shaktiman 1 was rated as moderately susceptible while the remaining genotypes were categorised as susceptible (RHM 2, PEHM 2) and highly susceptible (VH 4, VH 5, VH 9, VH 23, Shaktiman 2, Shaktiman 3, PEHM 5, RHM 1) to *S. oryzae*. The reason for variation in susceptibility could be due to antibiosis and non preference as mechanism of resistance. Grain damage and weight loss were

Table 1. Maize genotypes and extent of grain damage, weight loss and adult emergence (*Sitophilus oryzae*)

Genotypes	Adult emergence	Seed damage (%)	Weight loss (%)
VH5	72± 8.67 (8.45)[b]	24.50 ± 2.60 (29.71)[c]	1.52± 0.81(6.28)[abc]
VH9	72± 2.89(8.48)[b]	33.0±1.40 (35.00)[d]	2.54±0.14 (9.16)[c]
VH4	50± 9.07 (6.76)[b]	23 ±7.43 (26.14)[b]	0.90 ± 0.37(5.16)[ab]
Shaktiman2	85 ± 6.01(8.98)[b]	26 ± 5.93(31.22)[b]	2.70 ± 0.78(9.35)[c]
RHM2	40 ± 8.67(6.32)[b]	17.00± 3.53 (23.60)[b]	0.73 ± 0.03(4.90)[ab]
RHM1	41± 5.81(6.48)[b]	33.5 ± 1.45(35.25)[d]	2.43±1.10(8.38)[c]
Shaktiman1	10± 5.78 (2.54)[a]	12 ± 2.69(19.98)[a]	0.29± 0.16(2.48)[a]
VH23	40 ± 0.57(6.32)[b]	18.5±2.60 (25.24)[b]	1.14 ± 0.52(5.71)[ab]
Shaktiman3	53± 7.63(7.08)[b]	18 ± 7.69(25.74)[b]	0.85± 0.49(4.26)[a]
PEEHM5	228 ± 4.74(15.09)[c]	48.5± 0.33(44.04)[e]	2.76±0.73 (9.38)[c]
PEEHM2	44 ± 3.18(6.65)[b]	17.5 ±3.18 (24.42)[b]	2.0± 0.31(8.08)[c]
CV	23.48	19.37	39.75

Each value is mean of three replicates. Figures in parantheses are angular (% seed damage, % weight loss) and square root (F1 progeny emerged**)** transformed values. Means followed by the same letter are not significantly different (P> 0.05).

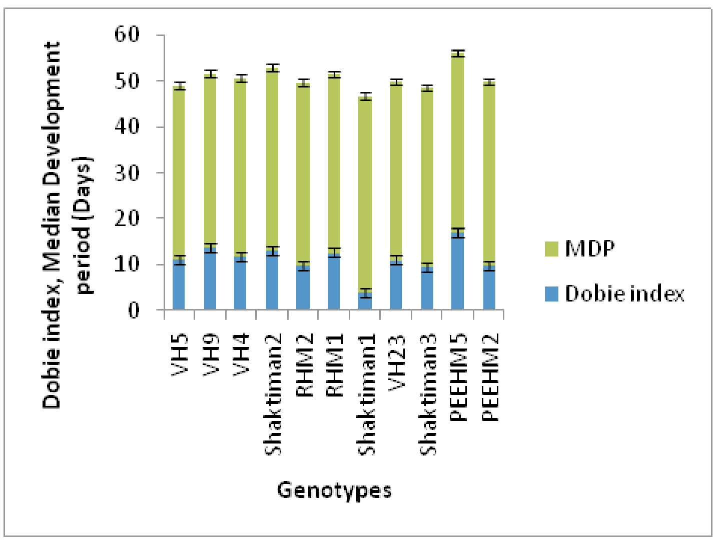

Fig.1. Maize genotypes and susceptibility index and development period (*Sitophilus oryzae*)

positively related with adult emergence (Figs. 3 and 4). The results observed herein agree with Abebe *et al*. (2009) who studied the resistance of maize varieties to *S. zeamais*. However, adult emergence (0.7511), seed damage (0.7296) and weight loss (0.7994) showed a significant positive relationship with the susceptibility index. Bergvinson (2001) reported that various physical characteristics such as kernel hardness and pericarp traits were identified as mechanisms of kernel resistance against the maize weevil. It might be due to non preference based on lack of feeding stimulus in the resistant kernels (Khattak *et al*., 1988). Ranason *et al*. (1992) reported that resistance in maize grain to the weevil was also contributed by the anti-feedant effect of phenolic compounds and weight loss of grains was negatively correlated to total phenolics in the grain. In resistant lines undamaged pericarp acted as a barrier against feeding and low levels of antibiosis in endosperm were found which was expressed by prolonged development period resulting in emergence of smaller than average weevils (Schoonhoven *et al*.,1975). High adult emergence caused high weight loss, which is clear indication of susceptibility.

The emergence of angoumois grain moth, seed damage and weight loss are given in Table 2. Minimum adult emergence was in VH 5 (12.50) followed by Shaktiman 2 (15) while the highest was observed in PEEHM 5 (63) followed by VH 9 (58.50) and consequently high seed damage (63.15%, 48.27%) and weight loss (14.27%, 10.13%), respectively. Comparatively low seed damage and weight loss was inflicted in VH 4 (4.28%, 2.74%) and VH 5 (6.70%, 2.86%) genotypes, respectively. However, none of the genotypes showed resistance to *S.cerealella*. The development period ranged from 30 days for VH 23, PEEHM 5 and 38.00 days for VH 4. The index of susceptibility ranged from 3.28 in VH 5 and 10.69 in RHM 2 (Fig. 2). The susceptibility index of both species was inversely related with development time. Similar to rice weevil damage and weight loss were positively related with adult emergence of *S. cerealella* (Figs. 5 and 6). The present results corroborate with Shafique and Chaudry (2007) who reported the correlation between adult progeny of *Rhizopertha dominica* and *S. cerealella* and weight loss in maize

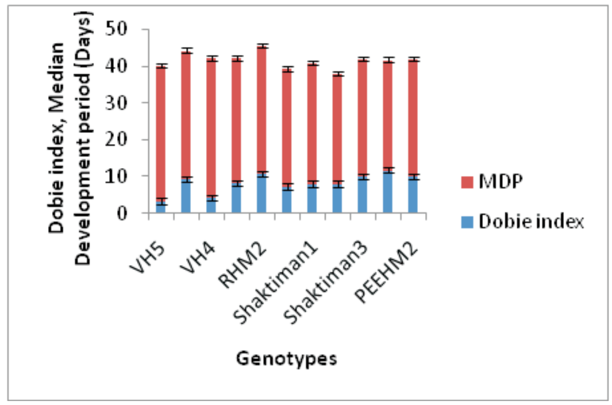

Fig. 2. Susceptiblity and median development period (*S.cerealella*)

Table 2. Maize genotypes and extent of grain damage, weight loss and adult emergence of (*Sitotroga cerealella*)

Genotypes	Adult emergence	Seed damage (%)	Weight loss (%)
VH5	12.50 ± 1.44(3.59)[a]	6.70 ± 0.84(14.94)[a]	2.86 ± 0.17(9.72)[a]
VH9	58.50 ± 0.28 (7.68)[b]	48.27±3.75 (43.91)[c]	10.13 ± 1.53(18.45)[bc]
VH4	24.00 ± 2.31 (4.93)[ab]	4.28 ± 0.03(11.93)[a]	2.74 ± 0.10 (9.52)[a]
Shaktiman2	15.00 ± 2.81 (3.90)[a]	15.46± 2.01 (23.06)[a]	4.47± 0.05 (12.20)[a]
RHM2	28.50 ± 0.28 (5.38)[ab]	26.47 ± 1.92(30.93)[c]	4.76 ± 0.25(12.59)[ab]
RHM1	17.50 ± 0.28 (4.24)[a]	19.50 ± 1.27(30.47)[c]	4.60 ± 2.65 (15.83)[b]
Shaktiman1	23.50 ± 0.28 (4.89)[ab]	27.25 ± 3.55(31.43)[c]	4.93 ± 0.32 (12.81)[ab]
VH23	21.00 ± 1.73 (4.62)[ab]	27.25 ± 4.76(31.29)[c]	4.49 ± 0.45 (12.20)[a]
Shaktiman3	40.50 ± 3.17(6.39)[b]	12.24 ± 7.07(26.48)[b]	3.90 ± 2.25 (14.46)[b]
PEEHM5	63.00± 9.65 (7.75)[b]	63.15 ± 1.35(52.63)[a]	14.27 ± 1.64 (22.12)[c]
PEEHM2	25.00 ± 2.31 (5.03)[ab]	38.35 ± 0.35 (38.26)[d]	12.48 ± 0.17 (20.68)[c]
CV	14.04	18.27	11.42

Each value is mean of three replicates. Figures in parantheses are angular (% seed damage, % weight loss) and square root (F1 progeny emerged**)** transformed values. Means followed by the same letter are not significantly different (P> 0.05).

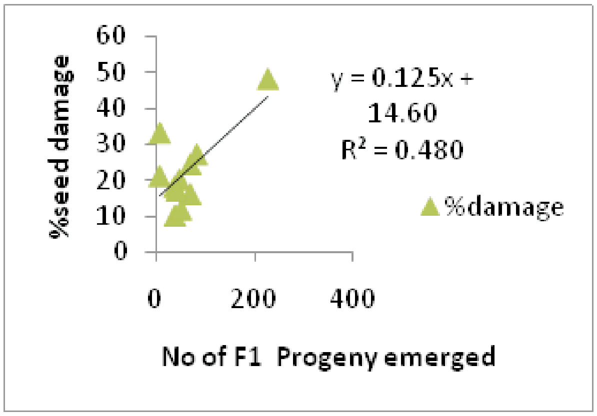

Fig. 3. Correlation between grain damage and F1 progeny *(S.oryzae)*

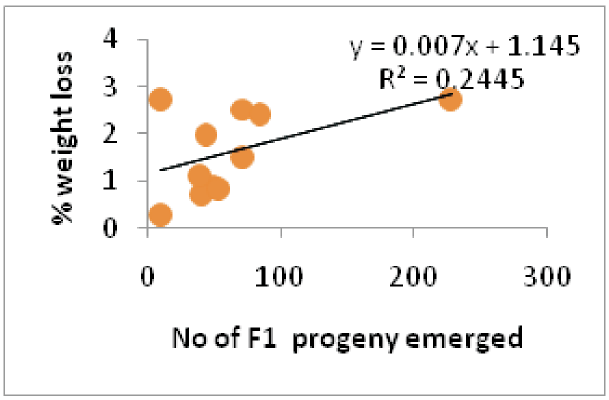

Fig. 4. Correlation between % weight loss and F1 progeny (*S.oryzae)*

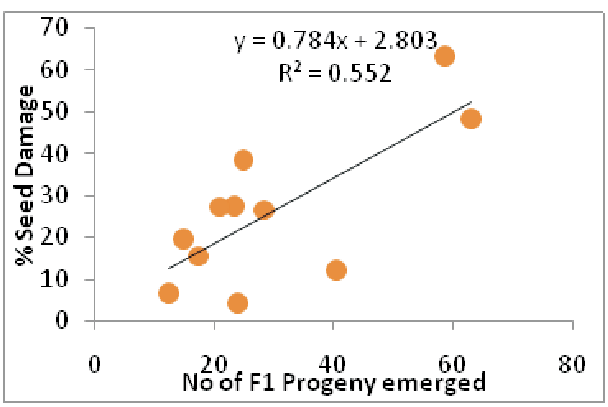

Fig. 5. Correlation between seed damage and F1 progeny *(S. cerealella)*

genotypes was significantly positive. The genotypes VH 4 and VH 5 were rated as moderately susceptible while the remaining as highly susceptible. The correlation between susceptibility index and adult emergence of *S. cerealella* (0.6743), seed damage (0.7403) and weight loss (0.6726) were positive and significant. Considerable variation was found among

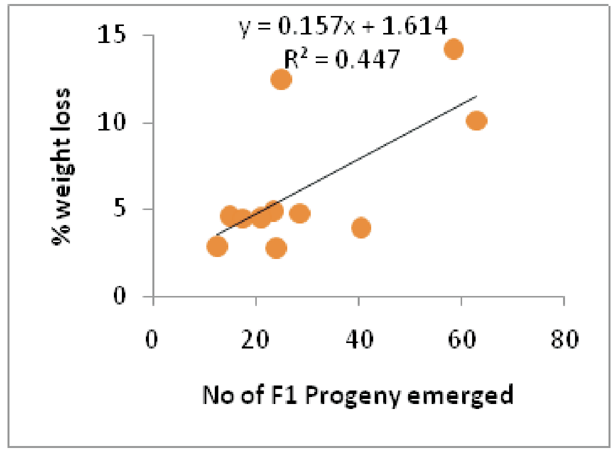

Fig. 6. Correlation between per cent weight loss and F1 (*S. cerealella*)

the maize genotypes with respect to adult emergence, seed damage, grain weight loss and susceptibility index which indicate the inherent ability of a particular genotype to resist the infestation. The least susceptible or moderately susceptible genotypes can be utilized as an ecofriendly way to reduce damage by insect pests under traditional storage conditions.

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