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Evaluation of specialty corn inbreds for responses to stored grain weevil (*Sitophilus oryzae* L.) infestation

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Abstract

Evaluation of a diverse set of 68 specialty corn inbreds (pop corn, sweet corn and QPM) against stored grain weevil (*Sitophilus oryzae* L.) revealed existence of wide genetic variations for grain weight loss (3.40-41.21%), number of insect progeny emerged (5.00-76.33), germination of seeds after infestation (0.00-81.33%), pericarp thickness (36.18-178.13 µm) and grain hardness (62.33-600.33 Newton). Pop corn inbreds recorded lowest mean grain weight loss (8.19%) and number of insect progeny emerged (9.23) with highest mean germination (78.28%). Grain weight loss and number of insect progeny emerged were positively correlated, while both showed negative correlation with germination percentage. Pericarp thickness and grain hardness could not contribute to confer resistance. Based on cumulative resistance index (CRI), pop corn inbreds were in general more resistant (mean CRI=1.84) to weevil infestation as compared to shrunken sweet corn (mean CRI=1.51), sugary sweet corn (mean CRI=1.26) and QPM (mean CRI=0.76) inbreds. However, resistant inbreds were also identified in sweet corn and QPM types that can be utilized effectively as donors in the resistance breeding programme. The contrasting inbreds could serve as rich genetic resources for unravelling the basis of resistance.

Key words: Storage pest, weevil, resistance, specialty corn, *Sitophilus oryzae*

Maize (*Zea mays* L.) serves as a rich source of carbohydrates, proteins and minerals; and provides energy to vast majority of people worldwide [1]. Further, it is becoming popular for its diversified usage as such as pop corn, sweet corn and nutritionally enriched quality protein maize (QPM) [1, 2]. In many of the South Asian countries, major portion of the maize produce is used as poultry feed, while considerable proportion is used for human food as well [3]. Depending on the climatic and storage conditions, maize grains are infested by a wide array of stored insect pests, of which rice weevil (*Sitophilus oryzae* L.) has emerged as one of the voracious feeders of cereal grains; and it is ubiquitously present in most of the South Asian countries including India [4]. Due to polyphagous nature, rice weevil causes significant post-harvest losses to maize grains. In developing countries, grains are generally stored in jute bags which often absorb moisture during rainy season and create favourable conditions for weevil infestation [5]. Besides damaging the grains, weevil infestation causes reduction in seed germination and invites fungus infection that leads to synthesis of harmful toxins on the food grains [6]. Development of host plant resistance through crop breeding is a favoured approach owing to its environmental safety, relatively low cost, no harmful effects on human health, and ease of use by farmers [7]. Hence, understanding the level of responses of different maize inbreds especially against *S. zeamais* infestation assumes importance to decide the course of resistance breeding strategy. Though various reports on responses of traditional/normal maize inbreds especially against *S. zeamais* are available, but the comprehensive analyses of performance of different specialty corn inbreds upon *S. oryzae* infestation has not been undertaken so far. Thus the present study was aimed to: (i) compare the responses of different specialty corn genotypes against weevil infestation; and (ii) study the relationships of various characters determining the level of weevil infestation among specialty corn inbreds.

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Materials and methods

A total of 68 specialty corn genotypes comprising 7 pop corn, 39 sweet corn [23 sugary and 16 shrunken] and 22 QPM were selected to evaluate their responses against rice weevil (*S. oryzae*) infestation. DMRQPM-60 (with hard endosperm kernel) and MGQSO-370 (with soft opaque kernel) were chosen as resistant and susceptible checks, respectively. The study was undertaken in a completely randomized design with 3 replications. Characters *viz*., grain weight loss (%), number of insect progeny emerged, germination (%), pericarp thickness and grain hardness were recorded.

Twenty five kernels of each inbred were analyzed for their responses against rice weevil infestation. Kernels of each genotype were cleaned and brought to moisture level of ~15% and were weighed, and kept in plastic petriplate with a ventilated lid. Eight pairs of unsexed adult insects were placed in each of petriplates for oviposition for a period of seven days [5, 8]. After seven days, the released insects were taken out and the petriplates with seeds were kept in an incubator at 28±2^{o} C and 70±5% relative humidity. Thirty days after incubation, the petriplates were monitored regularly for progeny emergence. After commencement of weevil emergence, progenies were counted and removed from each petriplate on every alternate day for a period of next 40 days. After completion of experiment, grain weight loss was recorded and total number of insect progeny emerged was computed. The characters such as pericarp thickness and grain hardness were recorded on non-infested grains through ocular micrometer calibrated in compound microscope and texture analyzer, respectively. Germination test on infested grain was carried out after the completion of infestation experiment. The data thus generated were analyzed for Analysis of Variance (ANOVA) using SAS Version 6.12. Pearson's simple correlation coefficients were estimated using Office-Excel 2007. Cumulative resistance index (CRI) was generated as per Arunachalam and Bandopadhyay [9].

Results and discussion

ANOVA revealed significant differences for grain weight loss (range: 3.40-41.21%), number of insect progeny emerged (range: 5.00-76.33), germination percentage (range: 0.00-81.33%), pericarp thickness (range: 36.18-178.13 µm) and grain hardness (range: 62.33-600.33 Newton), suggesting the availability of adequate genetic variation amenable to genetic improvement (Tables 1 and 2). The average grain weight loss among pop corn inbreds was 8.19%, while the same was 12.09%,

Table 1. ANOVA for different characters studied for weevil infestation

Source of variation	df	Mean squares				
		WL	NIP	GP	PT	GH
Genotypes	67	263.26**	544.75**	1991.98 **	1917.46**	44803.00 **
Error	136	8.43	12.39	59.45	116.04	1685.00
Total	203	-	-	-	-	-

**Significance at 0.01; WL- weight loss; NIP- number of insect progeny emerged; GP- germination percentage; PT- pericarp thickness; GH- grain hardness

Table 2. Genetic variability of different characters among specialty corn inbreds

Inbred lines	Variation	WL (%)	NIP	GP	PT (µm)	GH (Newton)	CRI
Pop corn	Range	5.59-10.11	7.00-12.00	74.67-81.33	80.72-128.03	208.67-421.00	1.74-1.91
	Mean	8.19	9.23	78.28	106.56	314.71	1.84
Sugary (sweet corn)	Range	3.40-25.55	7.00-33.67	0.00-57.33	36.18-125.25	76.00-536.67	0.26-2.64
	Mean	12.09	12.47	21.91	90.64	267.91	1.26
Shrunken (sweet corn)	Range	4.12-27.73	5.00-25.00	0.00-50.67	72.37-119.68	62.33-578.67	0.51-2.36
	Mean	12.64	9.66	21.41	89.15	160.74	1.51
QPM	Range	8.85-41.21	6.33-76.33	0.00-76.00	41.75-178.13	113.00-600.33	0.12-2.53
	Mean	26.59	29.68	13.27	90.91	287.72	0.76
	CD (5%)	6.59	5.68	12.45	17.39	66.28	-

WL- weight loss; NIP- number of insect progeny emerged; GP- germination percentage; PT- pericarp thickness; GH- grain hardness; CRI: Cumulative resistance index; Higher value of CRI indicates higher degree of resistance

12.64% and 26.59% in sugary, shrunken and QPM inbreds, respectively. The average number of insect progeny emergence was 9.23 in pop corn, 9.66 in shrunken, 12.47 in sugary and 29.68 in QPM genotypes. The pop corn inbreds recorded the highest mean germination percentage (78.28%), whereas sugary, shrunken and QPM inbreds had average germination of 21.91%, 21.41% and 13.27%, respectively. It is interesting to note that, though sweet corn (both sugary and shrunken) were comparable to pop corn genotypes for grain weight loss and number of insect progeny emerged, but germination in the infested grains of sweet corn inbreds were highly affected. This is possibly due to the fact that sweet corn inbreds contain less starch in the endosperm, and even a lesser damage in the endosperm by weevil infestation causes substantial damage in germination.

The association among different characters revealed strong positive correlation (r= 0.83) between grain weight loss (%) and number of insect progeny emerged (Table 3). Similar results showing association among these characters in normal inbred lines were reported earlier [5, 8, 10]. The study also confirmed negative correlation of germination percentage with grain weight loss (r= –0.60) and number of insect progeny emerged (r= –0.51) (Table 3). Earlier reports suggested positive correlation between pericarp thickness and weevil resistance, as the snout penetration by the weevil into the grains depends on the thickness of the pericarp [11-13]. However, in the present investigation, we observed no correlation between pericarp thickness with either of grain weight loss and insect progeny emerged. Gomez *et al*. [14] has also concluded no association of pericarp thickness with weevil resistance. This is also evident from the fact that the resistant check, DMRQPM-60 had a pericarp thickness of 50.10 µm, while susceptible check, MGQSO-370 had a pericarp thickness of 97.42 µm. These results therefore, indicated that pericarp thickness may not be a key factor for imparting resistance against weevils. Bergvinson [12] reported that the snout penetration by the weevils into the grain depends on it hardness and the studies conducted by Siwale *et al*. [15] and Ruswandi *et al*. [16] also supported this hypothesis. However, we observed here lack of correlation between grain hardness with grain weight loss and insect progeny emergence [17, 18].

Table 3. Correlation among the characters studied for weevil infestation

Characters	NIP	GP	PT	GH
WL	0.83**	–0.60**	–0.17	0.07
NIP		–0.51**	–0.20	0.09
GP			0.29*	0.28*
PT				0.03

*,**Significance at P=0.05 and 0.01 respectively; WL- weight loss; NIP- number of insect progeny emerged; GP- germination percentage; PT- pericarp thickness; GH- grain hardness

The results thus showed that grain weight loss, number of progeny emerged and germination percentage are associated with weevil resistance, while pericarp thickness and grain hardness do not contribute to impart resistance. Therefore, above three characters were considered for generating CRI. The mean CRI for the pop corn inbreds was 1.84, while sugary and shrunken types had a mean CRI of 1.26 and 1.51, respectively. QPM genotypes were susceptible with low CRI (0.76). The study therefore, suggests that generally, pop corn genotypes possess inbuilt resistance mechanism, while QPM genotypes are highly susceptible to weevil infestation. Sugary type sweet corn inbreds are more susceptible as compared to shrunken type sweet corn inbreds, possibly due to the fact that less starch in shrunken endosperm is not much preferred by the weevils, which feeds more on sugary endosperm that contains more starch.

Since, physical barrier such as thickness in pericarp and hardness in grains do not contribute to weevil resistance, biochemical properties such as α-amylase- and protease- inhibitors [19, 20] and phenolics [10], may explain the basis of resistance to weevil infestation. Further, resistant- (pop corn) and susceptible- (QPM) inbreds identified in the study, could serve as excellent genetic materials for unravelling the basis of weevil resistance. However, some inbreds of QPM type, had higher CRI value than the maximum value achieved in pop corn inbreds (Table 2), thereby indicating the possibility of existence of more complex mechanism of resistance. Further, despite having inherent susceptibility to weevil infestation, it is possible to identify resistant -QPM and -sweet corn inbreds that can serve as potential donors in the resistance breeding programme.

The present study thus reports here the existence of sufficient variation for weevil resistance among specialty corn genotypes, thereby providing immense opportunity to impart weevil resistance through genetic means. Grain weight loss, number of insect progeny emerged and germination after weevil infestation are the important characters for resistance to weevil infestation. In general among the various specialty corn inbreds, pop corn genotypes possess resistance, while QPM genotypes are highly susceptible. These specialty corn inbreds could serve as contrasting genetic resources for unravelling the biochemical basis resistance. Pop corn, sweet corn and QPM inbreds with high CRI can be utilized effectively as donors in the resistance breeding programme.

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