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Susceptibility of Maize Grains to Storage Insects

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Abstract.- Grains of seven elite maize genotypes were evaluated for their comparative resistance to lesser grain borer, *Rhyzopertha dominica* (F). and Angoumois grain moth, *Sitotroga cerealella* (Olivier) on free choice basis under laboratory conditions (28±2°C and 60±5% RH). Progeny of emerging adults and weight loss of grains were taken as parameters to check resistance. The results indicated that adult progeny of both species and weight loss of grains were significantly low in White Monsanto ex-Cargil and Yellow Pioneer. However, significantly high number of adults were developed in yellow 2303, Waxy and Yellow 6525 Cargil with higher weight loss of grains. The correlation between adult progeny and grain weight loss in maize genotypes was significantly positive. Whereas the correlation between progeny of insect species was non-significant showing their independent development. The results suggested that resistant varieties could be incorporated in maize breeding programme to decrease the postharvest losses of grains.

Key Words: Maize grain, resistance, lesser grain borer, Angoumois grain moth, adult progeny, grain weight loss.

INTRODUCTION

Maize *(Zea mays* L.) is the third important cereal and cash crop of Pakistan. During 2003-04, maize was cultivated on about 0.95 million hectares, producing 1.9 million tonnes of grain with 2003 kg/hectare yield (MINFAL, 2004). Maize grains are rich source of carbohydrates, protein, oil and minerals for humans and animals alike. Many value added corn based products and ingredients are manufactured that are used in textile, paper and corrugation industries, food products, confectionery, baking, pharmaceutical, animal health and nutrition. Starch based ingredients have significant value in textile and paper industries in the country. Pakistan is one of the important suppliers of maize starch in the world (Ali, 2004). During postharvest storage, maize grains are vulnerable to many insects. Among those, Angoumois grain moth *Sitotroga cerealella* (Olivier), lesser grain borer *Rhyzopertha dominica* (F.), weevils complex *Sitophlilus* spp., Khapra beetle *Trogoderma granarium* Everts and red flour beetle *Tribolium castaneum* (Herbst) are very important (Schoonhoven *et al.*, 1975; Atwal, 1976; Qayyum, 1982; Wahla *et al.*, 1984; Irshad *et al.*, 1988; Lohar *et al.*, 1997; Ebeling, 2002).

It is estimated that 5 – 2 10% of world's grain production is lost due to ravages of insect pests. These losses reach to 50% in tropical countries where temperature and humidity run high during summer season (Ahmad, 1983; Maqsood *et al.*, 1988; Irshad *et al.*, 1988; Ahmad and Ahmad, 2002). Control of these insect pests by insecticides give residues and develop insect resistance. To reduce grain losses in stores, insects resistant varieties are of particular interest for developing countries. Lot of variation has been reported in grains for resistance to storage insects (Singh and Pandey, 1974; McGaughey *et al.*, 1990; Hamed and Khan, 1994; Hamed and Khattak, 1997; Shafique and Ahmad, 2003). Keeping in view the food value and economic importance of maize grains, studies on relative susceptibility of seven new genotypes were conducted under laboratory conditions.

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MATERIALS AND METHODS

Grains of seven maize cultivars (Yellow Pioneer, Yellow 2303, Yellow 3335, Yellow 6525 Cargil, Waxy, Waxy 2213 and White Monsanto ex-Cargil), procured from Rafhan Maize Products Co. Ltd., Faisalabad were screened for susceptibility to lesser grain borer (*Rhyzopertha dominica* F.) and Angoumois grain moth *(Sitotroga cerealella* Oliv.) under laboratory conditions (28±2°C and 60±5% RH) during 2005. Maize samples were cleaned and preconditioned at 5°C for two weeks. Insects reared in the laboratory were utilized for maize grain resistance studies as explained below.

R. dominica

Grain sample (25 g) of each cultivar kept on glazed paper was placed in a circle in Perspex chamber and 50 one-week old adults of *R. dominica* were released in the center for free choice feeding/oviposition. The experiment was replicated three times. After 7 days, the beetles were removed. The grains with eggs of beetle were shifted in glass jars of 150 g capacity and covered on top with perforated tin lids. After completion of 2 generations (90 days), *R. dominica* adult progeny produced in each sample was counted and recorded. The grain weight loss of each infested sample was recorded after sieving the frass through 12 mesh screen. Percent weight loss was determined using control samples.

S. cerealella

Grain sample (25g) of each cultivar was placed on glazed paper in an octagonal perspex chamber and one-day old moths (10 pairs) of S. *cerealella* were collected from stock culture and released in the chamber from top hole for free choice oviposition on maize grains. The experiment was replicated three times. After 7 days, the moths (dead/live) were removed. The grain samples with moth eggs were kept in glass jars of 150g capacity and covered on top with perforated tin lids. After completion of experimental period (90 days), the total adults produced including the moth carcasses were counted. Each sample was sieved through 12 mesh screen and the dust passed through was discarded. The samples were reweighed to determine weight loss. Weight loss was determined by subtracting the value of infested maize from that of the controls.

R. dominica *and* S. cerealella

In this experiment, 50 g sample of each cultivar was placed in perspex chamber and 50 one-week old adults of *R. dominica* and 10 pairs of one-day old *S. cerealella* moths were released in the chamber for free choice feeding/oviposition on maize grains. The experiment was replicated three times. After 7 days, the grains of each sample were shifted to 150 g capacity glass jars as explained earlier. Dead/alive adults of *R. dominica* and moths of S. *cerealella* were removed from samples. After the expiry of experimental period (90 days), the adult progeny of *R. dominica* and S. *cerealella* produced in each replicate was recorded. The infested samples were sieved to remove dust/frass. The samples were reweighed and grain weight loss was determined using control samples.

The data recorded in these experiments were subjected to analysis of variance and significant means were compared using Duncan's new multiple range test at 5% level of significance. Coefficient of correlation (r) between different parameters in each experiment were determined (Steel and Torrie, 1980).

RESULTS

The adult progeny of lesser grain borer and weight loss of grains (Table I) varied significantly ($P<0.05$) in between cultivars. They were significantly low in White Monsanto ex-Cargil, Waxy 2213 and yellow Pioneer indicating high tolerance to *R. dominica.* Whereas adult progeny and grain weight loss were significantly high in Yellow 2303, Waxy and Yellow 6525 Cargil.

Moth progeny of Angoumois grain moth developed on maize cultivars and weight loss of grains (Table I) was significantly low in White Monsanto ex-Cargil, and Yellow Pioneer showing high tolerance to the insect. However, significantly high moth progeny developed in yellow 2303, Yellow 6525 Cargil and Waxy and consequently high weight loss of grains occurred in these maize cultivars. Comparing both the species together, it is evident that high moth progeny of S. *cerealella* was recorded in maize genotypes than adult progeny of *R. dominica.* Likewise, comparatively high grain weight loss was inflicted in maize cultivars infested by Angoumois grain moth.

The adult progeny of *R. dominica* and S. *cerealella* together (Table I) varied significantly ($P < 0.05$) between maize cultivars. It was significantly low in cultivar Yellow Pioneer and White Monsanto ex-Cargil. Likewise, weight loss of grains caused by these insects was also significantly low showing resistance to the test insects. However, adult progeny of these insects recovered from Yellow 2303, Waxy, and Yellow 6525 Cargil was significantly high. Weight loss of grains in these maize cultivars was also significantly high showing susceptibility to the test insects.

Table I.- Adult progeny of *Rhyzopertha dominica* and *Sitotroga cerealella* developed on maize and weight loss of grains.

Maize cultivars	*R. dominica*		*S. cerealella*		*R. dominica and S. cerealella*		
	Adult progeny (number)	Grain weight loss (%)	Moths emerged (number)	Grain weight loss (%)	Adult progeny (number)	Moths emerged (number)	Grain weight loss (%)
Yellow pioneer	21.00 d	6.41 e	68.67 d	16.92 e	30.67 d	53.33 d	15.66 d
Yellow 2303	103.00 a	21.47 a	130.00 a	34.76 a	97.33 b	168.67 a	36.58 a
Yellow 3335	51.33 c	9.25 d	97.67 c	24.88 d	59.33 c	1333.33 b	38.30 a
Yellow 6525 Cargil	82.33 b	14.66 c	124.67 ab	33.93 a	106.33 b	133.67 b	38.30 a
Waxy	106.33 a	18.61 b	117.67 b	29.28 b	153.33 a	108.33 a	35.57 a
Waxy 2213	19.67 d	6.78 e	90.67 c	27.31 c	92.67 b	112.00 c	28.81 b
White Monsanto ex-Cargil	19.33 d	6.16 e	52.33 e	12.53 f	32.33 d	98.00 c	20.40 c

Means sharing similar letters in each column are non-significant ($P < 0.05$).

Table II.- Correlation coefficient (r) **between insects adult progeny developed on maize and weight loss of grains.**

R. dominica		*S. cerealella*		*R. dominica and S. cerealella*		
Parameters	**Grain weight loss (%)**	**Parameters**	**Grain weight loss (%)**	**Parameters**	***S. cerealella* moths developed (number)**	**Grain weight loss (%)**
R. dominica adults progeny (number)	0.975**	*S. cerealella* moth progeny (number)	0.977**	*R. dominica* adult progeny (number)	0.461^{NS}	0.873**
				S. cerealella moth progeny (number)	-	0.772*

*Significant at 5% level, ** Significant at 1% level.

The correlation (Table II) between adult progeny of *R. dominica* and grain weight loss (0.975), moth progeny of *S. cerealella* and grain weight loss (0.977) and adult progeny of both *R. dominica* and *S. cerealella* and grain weight loss (0.873 and 0.772 respectively) were positive and significant. However, correlation between adult progeny of *R. dominica* and *S. cerealella* (0.461) was non-significant; which indicated that both the insects developed independently in maize cultivars without affecting development of each other.

DISCUSSION

The results clearly indicated that the adult progeny and grain weight loss of maize genotypes caused by *R. dominica* and *S. cerealella* individually as well as in combination varied significantly. Both parameters were significantly low in White Monsanto ex-Cargil and Yellow Pioneer. However, they were significantly high in yellow 2303, Waxy and Yellow 6525 Cargil. High tolerance in cereal grains to storage insects has been due to low adult progeny, prolonged development period and low weight loss of grains (Davis *et al.*, 1972; Wahla *et al.,* 1984; Khattak *et al.,* 1988;Li and Arbogast, 1991; Hamed and Khan, 1994; Michael *et al.*, 2000; Shafique and Ahmad, 2003). These arguments confirm that maize cultivars, White Monsanto ex-Cargil and Yellow Pioneer were highly tolerant to the test insects on the basis of low adult progeny with low grain weight loss. Contrary to that yellow 2303, Waxy and Yellow 6525 Cargil were found susceptible to insects.

Various physico-chemical characteristics of maize grains cause resistance to maize weevil, *Sitophilus zemais* (Mostsch.) during storage. Resistance was due to nonpreference and was based on lack of feeding stimulus in the resistant kernels (Wahla *et al.*, 1984; Khattak *et al.*, 1988). The undamaged pericarp acted as a barrier against feeding (Schoonhoven, 1976). However, broken/cracked maize grains were susceptible to *Tribolium castaneum* (Herbst) as significantly high population was developed on cracked grains than on intact grains (Khattak *et al.*, 1988; Li and Arbogest, 1991). Resistance in maize grains to the weevil was contributed by the anti-feedant effect of phenolic compounds and weight loss of grains was negatively correlated to total phenolics in the grain (Ranason *et al.*, 1992). Low levels of antibiosis in endosporm were found in resistant lines. This was expressed by prolonged progeny development period and weight. As a result smaller than average weevils emerged after a longer developmental period (Schoonhoven *et al.*, 1975).

High number of adult progeny caused high weight loss of grain, which is clear indication of grains susceptibility to the insects. Grains of White Monsanto ex-Cargil and Yellow Pioneer were comparatively resistant while Yellow 2303, Waxy and Yellow 6525 Cargil were found susceptible to *Rhyzopertha dominica* and *Sitotroga cerealella* infestation in storage. Knowledge of grain resistance based on physico-chemical characteristics and insect behaviour would help in decreasing the postharvest storage losses.

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