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Screening of Some Advanced Maize (*Zea mays* L.) Inbreds and Inheritance of Resistance against *C. partellus*

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ABSTRACT

Fifty well established, morphologically uniform and advanced inbreds of maize (Zea mays L.) were screened against stem borer (C. partellus) under artificial infestation conditions. Their average leaf injury rating varied, on 0-10 scale, varied from 3.8 to 8.4 thus none of the studied genotypes was found to be immune to the pest infestation. Out of the screened maize genotypes six highly resistant (335, 551-1, 645-3, 1324-A, 586-3 and 766(O)) and six susceptible (423, 1040-5, 323-8, 295, 877, 1015 (2+13)) genotypes were used for developing 35 F_1 *crosses. Responses of* F_1 *crosses to stem borer under artificial infestation conditions revealed that the crosses between resistant genotypes were resistant to stem borer infestation, while those between resistant × susceptible and susceptible × resistant were towards resistant side. However, the susceptible × susceptible crosses were susceptible to stem borer infestation. This indicated that resistance to stem borer in maize is dominant over susceptibility. The identified inbred lines variously resistant to C. partellus may be used as parents in hybrid breeding programmes that emphasize stem borer resistance or as sources of resistance in breeding programs.*

Key words: *Maize genotypes, C. partellus, Infestation, Susceptible.*

INTRODUCTION

Maize (*Zea mays* L.), belonging to family *Graminae*, is cultivated as an important multipurpose crop for providing food and fuel for human beings, feeds for animals, poultry and livestock. Maize grains have high nutritional value and are used as raw material for manufacturing a number of industrial products. It ranks third among cereals, in the world, after wheat and rice in terms of area and production. About 250 species of insects have been reported to attack maize crop during different stages of its growth causing damage to different parts of the plant[1]. Among these, *Chilo partellus* (Swinhoe) (*Pyralidae*: *Lepidoptera*) is the key pest not only throughout India but also in South-east Asia, Indonesia and Taiwan. Tropical environments are favorable for the insect development and lead to the formation of several generations of the pests in the same season causing heavy losses to the crop yield[2]. Hisar city (29.09^{0}N 75.43^{0}E) of Haryana state in India, is a hot spot for the maize crop's regular infestation with stem borer in *kharif*.

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Chilo partellus, commonly known as a maize stem borer or spotted stem borer, damages the maize plant from its early stage till the harvesting, resulting in serious yield losses[3,4]. Female moths lay eggs on the maize leaf lamina. Young larva causes damage by scrapping off chlorophyll in the leaf whorl and later on by feeding on the growing point. The third instar larva bores into stem and starts tunneling and the fully mature larva pupates inside the plant tissue[5]. Severe attack of this pest results in stunted plant growth, dead hearts (drying of the central whorl of the plant due to damage to growing point) and stem breakage, thus adversely affecting the yield.

Though the infestation of maize crop by stem borer can be controlled by using various insecticides[6-8], yet the extensive use of insecticides is not a viable strategy as it increases the cost of cultivation and environmental pollution. Further, the residual insecticides in the crop products and the nearby soil also lead to contamination of food and drinking water, causing a human health hazard. Also, the injudicious use of insecticides may cause ecological imbalance due to the killings of non-target species, insecticide resistance, pest resurgence and secondary pest outbreak. In view of the above problems associated with the chemical control of pests, host plant resistance to pest infestation seems to be an cost-effective, eco-friendly and viable alternative for managing the pest. Moreover, host plant resistance is also an important component of integrated pests management program.

Though plant structures may have negative or positive influence on herbivorous and their natural enemies[9,10], yet certain morphological characters of plant have been considered important in host plant resistance for *Chilo partellus*[11]. Maize germplasm showing relative resistance to *C. partellus* have, earlier, been reported by several workers[12-16] .

Trichomes on the leaf surfaces of the resistant genotypes have been reported to be related to low oviposition by *C. partellus*[17]. Various biochemical constituents such as poly-phenols, potassium, phosphorus, nitrogen and crude proteins have also been reported to influence the development, survival and incidence of maize stem borer[18,19]. Kumar[20] had reported that resistance in maize (*Zea mays* L.) to the stem borer *Chilo partellus* (Swinhoe) varied according to the phenological stage of crop, larval rearing medium, and developmental stage of the larvae.

While analyzing host plant resistance in some maize zenotypes against *Chilo Partillus* (Swinhoe), Afzal et al.[21] observed significant variations in the plant characters such as: plant and cob heights, number of nodes per plant, stem diameter, length of central spike, leaf area and trichomes and 100 grains weight. All these characters showed negative and significant correlation with the infestation of Chilo partellus. Tefera et al.[22] evaluated some maize hybrids for their resistance to stem borers, crop yield and foliar diseases in four agroecologies in Kenya. They observed, among the hybrids, significant variations in leaf damage, number of exit holes, tunnel length and grain yield. However, as stable sources of resistance are not yet available, therefore, there is a need for the identification more sources of resistance in Maize (*Zea mays* L.) against *C. partellus*. Murenga et al.,[23] have evaluated resistance of some tropical maize inbred lines against two stem borer species, *Busseola fusca* and *Chilo partellus*.

Some workers have reported that resistance to stem borer is inherited polygenically[24-26]. Singh[27] conducted inheritance studies on a collection of advanced inbred lines of maize developed from different indigenous and exotic populations for reactions to the stem borer. The developed crosses were identified for tolerance to the stem borer infestation and higher grain yield. Karaya et al,[28] used a partial diallel design for preparing F1 hybrids from some maize inbred lines to generate information on the values of these lines for developing insect resistant maize varieties. Leaf damage score, number of exit holes, cumulative tunnel length, and grain yield were measured as resistance traits.

Beyene *et al.*[29] used ten inbred parents with varying resistance levels to *Chilo partellus* and Busseola fusca and crossed these in a half diallel mating scheme to generate some F1 hybrids. They evaluated these hybrids and five commercial checks under artificial and natural infestation across four locations in Kenya. They observed that an inbred line resistance to a disease in one location may have a different reaction to the same disease in another location. Ali et al.[30] tested some hybrids as well as commercial maize genotypes for resistance/susceptibility against *Chilo partellus* (Swinhoe) with respect to physico-chemical plant traits. They found that commercial genotypes were more resistant than hybrids.

This paper reports on the screening results of 50 well established, morphologically uniform and advanced inbreds of maize (*Zea mays* L.) and some of the F1 crosses, derived from some selected resistant and susceptible genotypes, against stem borer (*Chilo partellus*) under artificial infestation conditions. The generated data may be useful in hybrid breeding programmes aimed for developing the pest resistant maize.

MATERIAL AND METHODS

Experimental Material

Seeds of 50 advanced inbreds of maize (table-1) were procured from Maize Section, Department of Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Uchani, Karnal, Twelve contrasting genotypes of Maize (*Zea mays* L.) comprising six resistant (335, 551-1, 645-3, 1324-1, 586-3 and 766(0)) and six susceptible (423, 1040-5, 323-8, 295, 877 and 1015 (2+3)) were selected to develop F_1 crosses for preliminary inheritance studies following artificial infestation method.

Table 1: List of maize genotypes evaluated for resistance against *C. partellus*

1.	3-4-1A	26.	1015 (2+3)
2.	3-4-7	27.	1015-6
3.	170 (1+2)	28	1015WG-8
4.	193-2	29.	1025
5.	295	30.	1032-3
6.	300-3	31.	1035-11
7.	323-8	32.	1040-3
8.	335	33.	1040-5
9.	368(O)	34.	1040-6D
10.	423	35.	1040-7
11.	488 E	36.	1105
12.	488 WG	37.	1324-1
13.	536 C	38.	1324-4
14.	551-1	39.	1324-A
15.	586-3	40.	1341
16.	645-3	41.	1344
17.	645-10	42.	1345
18.	645-13AWG	43.	1347 (1+2+3)
19.	690	44.	CML-150
20.	699(O)	45.	MBR-139
21.	766-2WG	46.	PC-3
22.	766(O)	47.	PC-8
23.	808 OY-2	48.	PC-9
24.	877	49.	PC-4B
25.	1011	50.	PCBT-3

Crop Field Study

The maize genotypes and their developed F1 Crosses were grown on Research Farm of Regional Research Station, Uchani in the augmented design (Figure 1) in a paired row of five meter length. Row to row and plant to plant spacing were maintained at 60 cm and 20 cm, respectively. All the recommended package of practices were followed except chemical control.

Fig. 1: Maize (*Zea mays* L.) crop grown at Research Farm of Regional Research Station, Uchani (Karnal). Each maize genotype planted in a paired row of five meter. Row to row and plant to plant spacing were 60 cm and 20 cm, respectively

Rearing of maize stem borer

A large number of stem borer (*C. Partellus)* larvae and pupae were collected from maize fields. The larvae were reared on cutpieces of fresh maize stem in the laboratory. To facilitate the entry of larvae into the food, the stem pieces were longitudinally split at both ends. These stem pieces were kept in glass jars (20 × 15 cm) covered with muslin cloth held tightly with rubber bands. The food was changed on alternate days till the larvae developed into pupae. The pupae were then transferred to a battery of jars, each 15 cm high and 10 cm in diameter, each layered at the bottom with 2 cm thick moist cotton and further covered with a filter paper (to avoid direct contact of pupae with the moist cotton). Each jar was covered with a piece of muslin cloth, tied securely with a rubber band[31].

Production of egg masses

Moths emerging from the pupae were transferred to glass jars each 15 cm high and 10 cm in diameter and lined inside with white butter paper. Four pairs of male and female were released inside each jar and then mouth of each jar was then covered with butter paper and a muslin cloth, tied securely with rubber band. Ten per cent sugar solution released on a cotton swab, as a feed for the moths. Butter paper containing egg masses was carefully cut into pieces of desired size to accommodate egg masses and these were then transferred to petridishes (Figure-2) provided with moist cotton swab until the eggs transformed to blackhead stage.

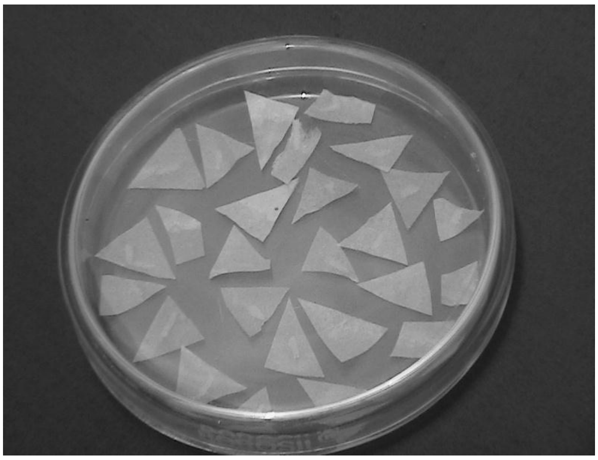

Fig. 2: Butter paper pieces containing egg mass of *C. partellus*

Leaf injury study

Butter paper pieces each containing 25 to 30 black head stage eggs and firmly pinned on thermocol were inserted in central whorls of 10 randomly selected, 15 days old maize plants. The plants thus infested were then tagged to facilitate subsequent observations. At 30 days, leaf injury ratings of studied maize genotypes were recorded following 1-9 rating scale due to Sarup *et al*.[32].

RESULTS AND DISCUSSION

Screening of maize genotypes

Response of studied maize genotypes to *C. partellus* scored as per the 1-9 leaf injury rating given by Sarup *et al*. [32] are presented in Table 2. It is observed that the studied maize genotypes exhibited varying response to the infestation of stem borer and none of the studied genotypes was found to be immune to stem borer infestation. During 2003 the average leaf injury scores ranged from 3.7 to 8.2. Genotype 335 was most resistant with average leaf injury score of 3.7. It was followed by 551-1, 586-3, 645-3, 645-10, 1324-A, 170 (1+2), 1324-1, 766(O). Inbred lines 1035-11, 1347 (1+2+3), 368(0), 645-13AWG, 1032-3, 1040-5, 1040-6D, 3-4-1A, 323-8, 423, 877, 1015 (2+3), 295 were the susceptible genotypes with mean leaf injury score ranging between 7.1 and 8.2. All other genotypes were intermediate in their response to *C. partellus* infestation.

The mean leaf injury rating data observed during the year 2004, also recorded in Table 2 and the results are more or less similar as obtained in the preceding year. Genotypes 335 and 586-3 were observed to be least susceptible with average leaf injury rating of 3.8 each. Dass *et al* [33] also reported genotype 586-3 to be resistant to stem borer. On the other hand, genotype 295 and 1015 (2+3) were most susceptible with mean leaf injury rating of 8.4 and 8.2, respectively. The identified maize inbred lines variously resistant to *C. partellus* may be used as parents in hybrid breeding programmes that emphasize stem borer resistance or as sources of resistance in breeding programs.

Table 2: Response of studied maize genotypes to *C. partellus* under artificial infestation conditions

Sr. No.	Genotype	Mean leaf injury rating	
		Year 2003	Year 2004
1.	3-4-1A	7.8	7.2
2.	3-4-7	6.7	5.8
3.	170 (1+2)	4.0	4.8
4.	193-2	6.1	7.4
5.	295	8.2	7.5
6.	300-3	5.3	7.1
7.	323-8	7.9	7.3
8.	335	3.7	3.8
9.	368(O)	7.3	8.0
10.	423	7.9	8.1
11.	488 E	5.2	6.3
12.	488 WG	4.4	4.7
13.	536 C	4.8	6.4
14.	551-1	4.1	3.9
15.	586-3	3.9	3.8
16.	645-3	4.2	4.7
17.	645-10	4.4	4.9
18.	645-13AWG	7.3	7.8
19.	690	4.9	4.2
20.	699(O)	5.8	5.1
21.	766-2WG	5.9	6.6

22.	766(O)	4.5	4.1
23.	808 OY-2	5.3	6.2
24.	877	8.0	7.9
25.	1011	5.9	7.4
26.	1015 (2+3)	8.1	8.2
27.	1015-6	4.8	5.2
28.	1015WG-8	5.7	6.9
29.	1025	5.7	6.1
30.	1032-3	7.4	7.9
31.	1035-11	7.1	5.3
32.	1040-3	6.1	5.8
33.	1040-5	7.6	7.0
34.	1040-6D	7.8	8.2
35.	1040-7	5.7	7.4
36.	1105	4.7	4.2
37.	1324-1	4.1	4.8
38.	1324-4	6.9	6.2
39.	1324-A	4.4	4.9
40.	1341	5.9	6.4
41.	1344	5.5	4.9
42.	1345	5.7	6.1
43.	1347 (1+2+3)	7.2	5.9
44.	CML-150	6.2	5.2
45.	MBR-139	6.4	6.5
46.	PC-3	6.3	5.7
47.	PC-4B	5.8	5.1
48.	PC-8	6.2	6.9
49.	PC-9	5.9	6.4
50.	PCBT-3	6.7	5.8

Inheritance of resistance study against maize stem borer

A set of twelve maize genotypes including six resistant (335, 551-1, 645-3, 1324-A, 586-3 and 766(0)) and six susceptible (423, 1040-5, 323-8, 295, 877 and 1015 (2+3)) were selected on the basis of *kharif,* 2003 and 2004 screening for studying inheritance of resistance against *C. partellus*. The observed responses of 35 F_1 crosses developed from the selected 6 resistant and 6 susceptible genotypes of Maize (*Zea mays* L.) against Stem Borer *(C. Partellus),* using leaf injury rating as a probe, are presented in Table-3.

The recorded leaf injury rating varied among the studied crosses, the minimum (3.9) being in 551-1 × 586-3 and 645-3 × 766(0) and the maximum (7.5) in 1040-5 × 877. The observed results also revealed that almost all the crosses between least susceptible parents were resistant to maize stem borer under artificial infestation conditions. Whereas, the response of most of the crosses between resistant × susceptible and susceptible × resistant were towards resistant. However, susceptible × susceptible crosses were highly susceptible to the infestation of maize stem borer indicating that least susceptibility dominants over high susceptibility.

Therefore, it can be inferred form the present studies that for the development of resistant hybrid/variety, the involvement of both or at least one resistant parent would be necessary. Earlier, whereas, Pathak and Olela[34] had reported partial dominance of resistance over susceptibility for stem borer in maize, later on, Pathak [25] had claimed that resistance was dominant over susceptibility.

Table 3: Responses of F_1 crosses developed from selected maize genotypes to *C. Partellus* under artificial infestation conditions using mean leaf injury rating, as a probe

Sr. No.	F_1 crosses	Type of cross	Mean leaf injury rating
1.	323-8 × 295	S × S	7.2
2.	323-8 × 586-3	S × R	4.9
3.	323-8 × 766(0)	S × R	5.6
4.	323-8 × 877	S × S	7.3
5.	323-8 × 1015 (2+3)	S × S	6.9
6.	335 × 295	R × S	4.5
7.	335 × 586-3	R × R	3.9
8.	335 × 766(0)	R × R	4.1
9.	335 × 877	R × S	5.1
10.	335 × 1015 (2+3)	R × S	5.0
11.	423 × 295	S × S	7.4
12.	423 × 586-3	S × R	4.7
13.	423 × 766(0)	S × R	5.4
14.	423 × 877	S × S	6.9
15.	423 × 1015 (2+3)	S × S	7.5
16.	551-1 × 295	R × S	5.0
17.	551-1 × 586-3	R × R	3.9
18.	551-1 × 766(0)	R × R	4.8
19.	551-1 × 877	R × S	4.9
20.	551-1 × 1015 (2+3)	R × S	5.4
21.	645-3 × 295	R × S	5.3
22.	645-3 × 586-3	R × R	4.2
23.	645-3 × 766(0)	R × R	3.9
24.	645-3 × 877	R × S	4.9
25.	645-3 × 1015 (2+3)	R × S	5.2
26.	1040-5 × 295	S × S	7.1
27.	1040-5 × 586-3	S × R	5.6
28.	1040-5 × 766(O)	S × R	5.1
29.	1040-5 × 877	S × S	7.5
30.	1040-5 × 1015 (2+3)	S × S	7.0
31.	1324-A × 295	R × S	6.1
32.	1324-A × 586-3	R × R	4.7
33.	1324-A × 766(O)	R × R	4.1
34.	1324-A × 877	R × S	5.0
35.	1324-A × 1015 (2+3)	R × S	4.8

CONCLUSION

Fifty morphologically uniform and advanced inbreds of maize (*Zea mays* L.) screened on the basis of leaf injury rating against stem borer (*C. partellus*), under artificial infestation conditions, revealed that none of the genotypes was immune to stem borer infestation. The identified inbred lines variously resistant to *C. partellus* may be used as parents in hybrid breeding programs that emphasize stem borer resistance or as sources of resistance in breeding programs. The studied F1 crosses between resistant × susceptible and susceptible × resistant were resistant, the susceptible × susceptible crosses were more susceptible to maize stem borer infestation. This shows that the resistance trait in maize was dominant over the susceptibility. Therefore, for the development of a new resistant hybrid/variety, the involvement of both or at least one resistant parent would be necessary.

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