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Symptom based artificial screening of promising maize germplasm against *Chilo partellus* (Swinhoe)

Ram Kumar, Tanweer Alam and Arbind Kumar Rai

Abstract
The present investigation was carried out at the research farm of the Tirhut College of Agriculture, Dholi, Muzaffarpur (Bihar) during *Kharif* 2016 to screen out the different maize germplasm against *Chilo partellus* (Swinhoe). The study revealed that among the different maize genotypes screened; IIMRQPMH 1608, FQH 106 and IIMRQPMH 1606 were found least susceptible while the genotypes IIMRQPMH 1604, IIMRQPMH 1502 and IIMRQPMH 1602 were found susceptible. Correlation result between plant height and the damage caused by *C. partellus* showed that percent plant infestation (-0.348), mean tunnel length (-0.439) and mean leaf injury (-0.332) evinced negative but non-significant effect on plant height. However, mean no. of exit holes (-0.514*) rendered negative and significant effect on plant height.

Keywords: *Chilo partellus*, screening, maize, germplasm

1. Introduction

Maize (*Zea mays* L.) is one of the most important cereal crop after wheat and rice, grown virtually in every suitable agricultural region of the world. It has been referred as the “Queen of cereals” due to its highest yield potential among all the cereals [3]. The average area, production and productivity of maize in India is 9.43 mha, 22.23 MT and 2.5 t/ha, respectively [4]. In India maize crop is attacked by 139 species of insect pests causing varying degree of damage. However, only about a dozen of these are quite serious cause damage from sowing till storage [21]. Among the various insect pests, maize stem borer, *Chilo partellus* is the most dominant contributing 90-95 percent of the total damage in *Kharif* season [8]. The loss primarily due to *C. partellus*, during *Kharif* at a conservative estimate comes to 110.5 crore annually [9]. The evolved technologies and chemical inputs that have proven harmful to M.Sc. (Ag.) research work human health and the environment need to be replaced with safer alternatives of moderately resistant varieties [15]; this is imperative for improving crop quality and productivity in the race to feed the burgeoning population. To combat the problem of yield loss due to stem borer damage in maize, chemical pesticides and use of resistant maize varieties are the available options suggested [11]. However, because of the high costs of chemical pesticides and their hazardous effects on human health and the environment, resistant maize varieties are being adopted in a number of countries. Also, chemical pesticides for the control of stem borers are often not so effective because borers are present in tunnel [11]. Keeping in view the above fact, the present objective was chosen to screen out the various promising maize germplasm against *Chilo partellus*.

2. Materials and methods

A field trial for screening of different QPM maize germplasm against maize stem borer was conducted at the research farm, Tirhut College of Agriculture, Dholi, Muzaffarapur (Bihar) during *Kharif* 2016. Twenty germplasm of quality protein maize including local check were screened out for their degree of susceptibility to stem borer, *Chilo partellus* under artificial infestation conditions. The crop was sown on July 27th, 2016. All the germplasm were sown in two rows and all the cultural practices were followed uniformly as per the local recommendation except insecticide application. Row length, row to row and plant to plant spacing were kept at 5.0 m, 60 cm and 25 cm, respectively. Laboratory culture of *Chilo partellus* was developed by collecting larvae and pupae during the first fortnight of July. These collected immature larvae were reared in two feet healthy maize stalk and pupae were kept in moth emergence cage.

The emerged moths were transferred to egg laying cages. Female moth started laying eggs on lined white papers inside the cage after 2-3 days. These laid egg masses turned into a black headed stage after 2-3 days of oviposition. The black headed stage of egg masses with paper bits were transferred into artificial diet vials for their further growth and development. The rearing process repeated to develop stock culture of neonate larvae.

Table 1: List of maize germplasm used for screening.

Sl. No.	Germplasm	Sl. No.	Germplasm
1.	QPM-MH-27	11.	KDQH-51
2.	IIMRQPMH 1501	12.	IIMRQPMH 1601
3.	VEHQ-16-1	13.	IIMRQPMH 1609
4.	IMHQPM 1530	14.	IIMRQPMH 1604
5.	IIMRQPMH 1608	15.	IIMRQPMH 1607
6.	IIMRQPMH 1605	16.	IIMRQPMH 1504
7.	IIMRQPMH 1603	17.	IIMRQPMH 1502
8.	FQH 106	18.	REHQ2014-11
9.	IIMRQPMH 1606	19.	IIMRQPMH 1610
10.	IIMRQPMH 1508	20.	Ganga safed-2 (local check)

All the plants in both rows were infested with five numbers of neonate larvae [10] at evening hours. The maize germplasm under test were closely examined at regular intervals. The observations pertaining to the different degree of symptoms were done according to methodology adopted [7].

Sl. No.	Injury symptoms	Score
1	Plants showing no. infestation symptoms.	1
2	1-2 leaves with pinholes.	2
3	3-4 leaves with holes.	3
4	1/3 of the leaves showing infestation symptoms.	4
5	1/2 of the leaves with infestation symptoms.	5
6	2/3 leaves with infestation symptoms and the holes becoming window.	6
7	Leaves with long window and plant growth are stunted.	7
8	Almost all leaves displaying heavy infestation and plant growth is stunted.	8
9	Dead heart formation observed.	9

The susceptibility/resistance to stem borer would be calculated by counting the number of injured leaves (1- 9 scale) by following the procedure of [7]. The leaf injury was recorded at 30 and 60 days after sowing. The mean of score of overall leaves injury of the pest to a particular germplasm were rated as per [4]. The leaf injuries were further categorized into three distinct groups of susceptibility *i.e.*, least susceptible 1-3, moderately susceptible >3-6, susceptible >6-9 to *Chilo partellus* [4].

The observations pertaining to the different groups were assessed for percent infestation. Extent of pest infestation for each germplasm was calculated by using the formula,

$$\text{Per cent plant infestation} = \frac{\text{Number of infested plants/plot}}{\text{Total number of plants/plot}} \times 100$$

The plant tunnel damage was assessed at harvest, ten randomly selected plants were cut from the soil surface in each germplasm, the stems were split open and the total number of exit holes on the stem made by borer was counted. The total length of stem and tunnel made by the larvae of stem borer was also measured and recorded. The intensity of pest infestation for each germplasm was determined by using the formula,

$$\text{Per cent stem tunneling} = \frac{\text{Tunnel length}}{\text{Plant height}} \times 100$$

In the context of susceptibility/resistance, the tunnel length was grouped into three distinct categories *i.e.*, least susceptible 0-5cm, moderately susceptible >5-10cm, susceptible >10 [11].

3. Results and discussion

Data given in Table 1 and illustrated in fig. 1, showed that the mean percent plant infestation ranged from 15.85 to 44.80 percent. Among the different tested maize germplasm, IIMRQPMH 1608 recorded minimum plant infestation (15.85 percent) and was statistically *at par* with FQH 106 (16.89) and IIMRQPMH 1606 (19.77). The germplasm IIMRQPMH 1604 recorded maximum plant infestation (44.80 percent) and was found statistically *at par* with IIMRQPMH 1508 (38.25 percent) and IIMRQPMH 1610 (38.14 percent). The remaining fourteen maize germplasm *viz*., IIMRQPMH 1609, QPM-MH-27, REHQ2014-11, IIMRQPMH 1607, IIMRQPMH 1605, IIMRQPMH 1603, KDQH-51, IIMRQPMH 1601, IIMRQPMH 1501, IIMRQPMH 1504, VEHQ-16-1, IIMRQPMH 1502, IMHQPM 1530 and Ganga Safed - 2 showed moderate level of plant infestation ranging from 21.99 to 37.65 percent. [11, 14] reported significant differences among the germplasm tested which provide a strong support to the present investigation [2]. Also stated that commercial maize varieties are more resistant to *C. partellus* infestation (5.63 to 8.73%) in comparison to hybrids (6.58 to 19.45) which is in agreement with the present observation.

Data pertaining to percent stem tunnelling, as summarized in Table 1 and depicted in fig. 1, clearly indicated that the mean percent stem tunnelling ranged from 2.73 to 21.43 percent. The minimum percent stem tunnelling (2.73 percent) was recorded in FQH 106 which was *at par* with IIMRQPMH 1606, IIMRQPMH 1608 and IIMRQPMH 1607 recording 2.95, 3.28 and 5.10 percent stem tunnelling, respectively. Four germplasm *viz*., QPM-MH-27, REHQ 2014-11 KDQH-51 and IIMRQPMH 1605, recorded significantly lower percent stem tunnelling (5.56, 6.04, 6.24 and 6.28 percent, respectively) than the local check *i.e*., Ganga Safed – 2 (12.77

percent). Seven germplasm *viz*., IIMRQPMH 1504, VEHQ-16-1, IIMRQPMH 1603, IIMRQPMH 1609, IIMRQPMH 1601, IIMRQPMH 1501 and IIMRQPMH 1508 recorded lower level of mean percent stem tunnelling ranging between 9.92 to 12.56 percent and were statistically *at par* with each other. However, four germplasm *viz*., IMHQPM 1530, IIMRQPMH 1502, IIMRQPMH 1604 and IIMRQPMH 1610 showed higher percent stem tunnelling (13.30, 18.0, 19.05 and 21.06 percent, respectively) than the local check *i.e*., Ganga Safed-2, (12.77 percent). [14, 16, 13] also made an attempt to study the host plant resistance against *Chilo partellus* (Swinhoe) on maize by assessing stem tunnelling percent in different maize cultivars which rendered significant variation.

A comparative perusal of the data presented in Table 1 and illustrated in fig. 1 indicated that out of twenty germplasm tested three germplasm *viz*., IIMRQPMH 1604, IIMRQPMH 1502 and IIMRQPMH 1610 recorded maximum mean leaf injury score (6.6, 6.3, and 6.2, respectively) and were grouped into susceptible germplasm to *C. partellus*. On the other hand, three germplasm *viz*., FQH 106 (2.3), IIMRQPMH 1608 (2.3) and IIMRQPMH 1606 (2.7) maintained their superiority over rest of the germplasm and were found to be less susceptible against *C. partellus.* The remaining fourteen germplasm *viz*., VEHQ-16-1, IMHQPM 1530, KDQH- 51, REHQ2014-11, QPM-MH-27, Ganga Safed-2, IIMRQPMH 1603, IIMRQPMH 1508, IIMRQPMH 1601, IIMRQPMH 1609, IIMRQPMH 1501, IIMRQPMH 1605, IIMRQPMH 1607, and IIMRQPMH 1504 registered mean leaf injury ranging from >3 to 6 and were grouped into moderately susceptible germplasm (Table 1). The above findings are in accordance with the finding of [5] who screened out 82 maize genotypes and revealed that leaf injury score ranged from 1.8 to 4.6 with a maximum leaf injury score in genotype MHQPM-09-5. [13] stated that leaf injury score varied from 2.6 to 6.6 among different tested maize germplasm with maximum and minimum being in QPM 169 and HUZQPM 242, respectively.

It was obvious that the maize germplasm exhibited significant variation in respect to plant height (Table 2 and fig. 2). The mean plant height varied from 126.7 to 166.2 cm. The lowest (126.7 cm) and the highest (166.2 cm) plant height were found in IIMRQPMH 1604 and IIMRQPMH 1508, respectively. The five germplasm *viz*., IIMRQPMH 1501 (132.0 cm), IIMRQPMH 1601 (139.0 cm), IIMRQPMH 1609 (136.7), IIMRQPMH 1610 (143.8 cm) and IMHQPM 1530 (133.8 cm) registered relatively lesser height and were *at par* with each other. Among the maize germplasm tested, two germplasm *viz*., IIMRQPMH 1508 (166.2 cm) and FHQ 106 (163.5 cm) established their superiority among all the germplasm and were statistically *at par* with each other. The six germplasm *viz*., QPM-MH-27 (156.7 cm), IIMRQPMH 1605 (155.3 cm), IIMRQPMH 1603 (151.4 cm), IIMRQPMH 1606 (154.8 cm), IIMRQPMH 1502 (153.6 cm) and KDQH-51 (156.0 cm) were found *at par* with IIMRQPMH 1508 (166.2 cm). The remaining germplasm *viz*., VEHQ-16-1 (141.4 cm), IIMRQPMH 1608 (148.3 cm), IIMRQPMH 1504 (145.9 cm), IIMRQPMH 1607 (150.5 cm), REHQ2014-11 (147.3 cm) were witnessed intermediate position.

It is discernible from the data in Table 2 and fig. 2, mean tunnel length among different germplasm differed significantly during entire crop season. The mean tunnel length was ranged widely from 4.4 to 27.4 cm with minimum and maximum being in FQH 106 and IIMRQPMH 1604, respectively. Among the maize germplasm tested, as many as three germplasm *viz*., FQH 106, IIMRQPMH 1606 and IIMRQPMH 1608 recorded 4.4, 4.5 and 4.8 cm tunnel length and were grouped as least susceptible germplasm. Moreover, five germplasm *viz*., IIMRQPMH 1607, REHQ 2014-11, QPM-MH-27, IIMRQPMH 1605 and KDQH-51 were grouped as moderately susceptible germplasm and evinced 7.5, 8.7, 8.7, 9.7 and 9.8 cm tunnel length. The remaining twelve germplasm (IIMRQPMH 1504, IIMRQPMH 1609, IIMRQPMH 1501, IIMRQPMH 1601, VEHQ-16-1, IIMRQPMH 1603, Ganga safed-2, IMHQPM 1630, IIMRQPMH 1508, IIMRQPMH 1610, IIMRQPMH 1502 and IIMRQPMH 1604) exhibited tunnel length in between 14.3 to 27.4 cm and were categorized as susceptible germplasm.

Data depicted in Table 2 and illustrated in fig. 2 clearly indicated that the mean number of exit hole varied from 4.0 to 14.3 per plant with minimum and maximum being in IIMRQPMH 1608 and IIMRQPMH 1604, respectively. Five germplasm *viz*., FHQ 106, IIMRQPMH 1606, IIMRQPMH 1504, QPM-MH-27 and IIMRQPMH 1607 had less number of exit holes (*i.e*., 4.5, 5.1, 5.8, 5.9 and 6.0 per plant) which were statistically *at par* with minimum number of exit holes in IIMRQPMH 1608 (4.0). As many as nine maize germplasm *viz*., REHQ2014-11, IIMRQPMH 1502, IIMRQPMH 1607, IIMRQPMH 1609, IIMRQPMH 1601, IIMRQPMH 1603, IIMRQPMH 1605, IIMRQPMH 1501 and VEHQ-16-1 under test recorded significantly more number of exit holes varying from 6.0 to 8.0 per plant, which were *at par* with each other and also with local check Ganga Safed-2. Remaining five germplasm *viz*., KDQH-51, IIMRQPMH 1508, IIMRQPMH 1610, IMHQPM 1530 and IIMRQPMH 1604 registered higher number of exit holes (8.1 to 14.3 per plant) than the local check.

3.1 Correlation between plant height and injury caused by *Chilo partellus*

The result of correlation analysis between plant height and the damage caused by *C. partellus* as depicted in table 3, suggested that percent plant infestation (-0.348), mean tunnel length (-0.439) and mean leaf injury (-0.332) evinced negative but non-significant effect on plant height. However, mean number of exit holes (-0.514*) rendered negative and significant effect on plant height. [6] Reported partially confirmatory results that plant height and number of infested nodes were adversely affected by *C. partellus* under severe infestation conditions. Other studies showed that *C. partellus* stem borer damage reduced the number of ears harvested per plant and plant height of maize [22] [19] [1].

Table 1: Plant infestation, stem tunneling and leaf injury score due to *Chilo partellus* (Swinhoe) in different maize germplasm under artificial infestation condition during *Kharif* 2016.

Sl. No.	Germplasm	Mean (%) plant infestation	Mean (%) stem tunneling	Mean leaf injury score/plant
01.	QPM-MH-27	22.71 (28.44)*	5.56 (13.62)*	3.1
02.	IIMRQPMH 1501	29.08 (32.61)	12.38 (20.59)	3.3
03.	VEHQ-16-1	34.90 (36.19)	11.59 (19.88)	3.6
04.	IMHQPM 1530	30.57 (33.55)	13.30 (21.38)	4.0
05.	IIMRQPMH 1608	15.85 (23.44)	3.28 (10.41)	2.3
06.	IIMRQPMH 1605	25.10 (30.03)	6.28 (14.50)	3.2
07.	IIMRQPMH 1603	26.10 (30.71)	11.72 (20.01)	3.1
08.	FQH 106	16.89 (24.23)	2.73 (9.34)	2.3
09.	IIMRQPMH 1606	19.77 (26.37)	2.95 (9.77)	2.7
10.	IIMRQPMH 1508	38.25 (38.18)	12.56 (20.71)	4.6
11.	KDQH-51	27.96 (31.90)	6.24 (14.44)	3.7
12.	IIMRQPMH 1601	28.68 (32.35)	11.83 (20.09)	4.0
13.	IIMRQPMH 1609	21.99 (27.70)	11.72 (20.01)	3.8
14.	IIMRQPMH 1604	44.80 (41.99)	19.05 (25.82)	6.6
15.	IIMRQPMH 1607	24.00 (29.32)	5.10 (12.99)	3.3
16.	IIMRQPMH 1504	30.38 (33.42)	9.92 (18.31)	3.9
17.	IIMRQPMH 1502	37.65 (37.83)	18.00 (25.01)	6.3
18.	REHQ2014-11	22.83 (28.52)	6.04 (14.14)	3.5
19.	IIMRQPMH 1610	38.17 (38.14)	21.06 (27.30)	6.2
20.	Ganga Safed-2 (C)	31.03 (33.83)	12.61 (20.79)	3.6
SEm (±)		(1.29)	(0.80)	0.24
CD (P=0.05)		(3.86)	(2.39)	0.74

*Figures in parentheses are the values of angular transformation.

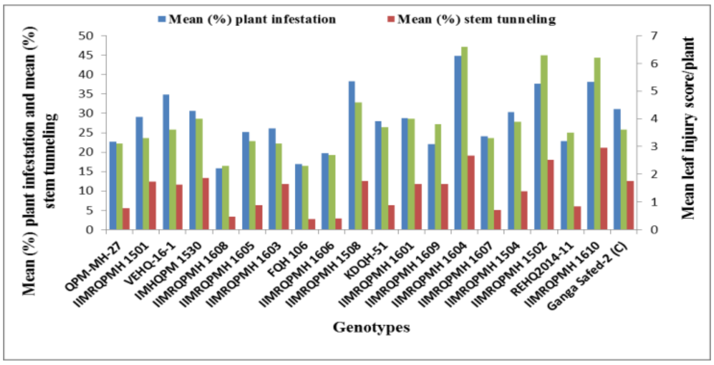

Fig 1: Plant infestation, stem tunneling and leaf injury score due to *Chilo partellus* (Swinhoe) in different maize germplasm under artificial infestation condition during *Kharif* 2016.

Table 2: Mean plant height, mean tunnel length and mean no. of exit hole due to *Chilo partellus* (Swinhoe) in different maize germplasm under artificial infestation condition during *Kharif* 2016.

Sl. No.	Germplasm	Mean plant height (cm)	Mean tunnel length (cm)	Mean no. of exit hole/plant
01.	QPM-MH-27	156.7	8.7	5.9 (2.62)*
02.	IIMRQPMH 1501	132.0	16.3	7.0 (2.82)
03.	VEHQ-16-1	141.4	16.3	7.5 (2.91)
04.	IMHQPM 1530	133.8	17.8	11.0 (3.45)
05.	IIMRQPMH 1608	148.3	4.8	4.0 (2.23)
06.	IIMRQPMH 1605	155.1	9.7	6.6 (2.75)
07.	IIMRQPMH 1603	151.4	17.6	7.5 (2.91)
08.	FQH 106	163.5	4.4	4.5 (2.34)
09.	IIMRQPMH 1606	154.8	4.5	5.1 (2.46)
10.	IIMRQPMH 1508	166.2	20.5	8.9 (3.14)
11.	KDQH-51	156.0	9.8	8.1 (3.01)
12.	IIMRQPMH 1601	139.0	16.3	8.0 (3.00)
13.	IIMRQPMH 1609	136.7	16.0	6.5 (2.73)
14.	IIMRQPMH 1604	126.7	27.4	14.3 (3.91)
15.	IIMRQPMH 1607	150.5	7.5	6.0 (2.64)
16.	IIMRQPMH 1504	145.9	14.3	5.8 (2.61)
17.	IIMRQPMH 1502	153.6	27.4	7.8 (2.96)
18.	REHQ2014-11	147.3	8.7	6.7 (2.77)
19.	IIMRQPMH 1610	143.8	26.6	10.9 (3.45)
20.	Ganga safed-2 (C)	141.4	17.8	7.4 (2.89)
SEm (±)		5.18	0.96	(0.09)
CD (P=0.05)		15.47	2.87	(0.29)

*Figures in parantheses are the values of square root transformaion.

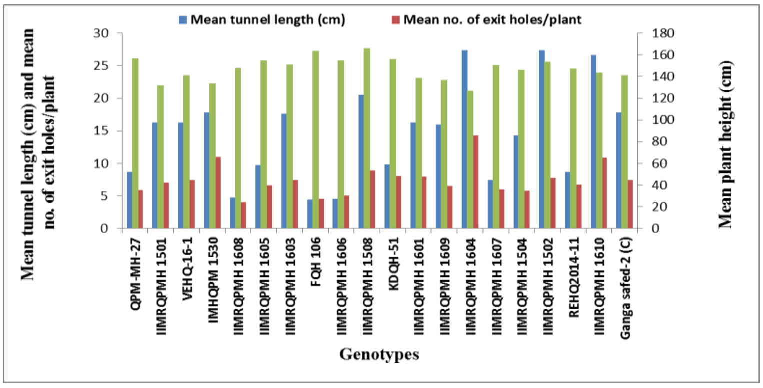

Fig 2: Mean plant height, mean tunnel length and mean no. of exit hole due to *Chilo partellus* (Swinhoe) in different maize germplasm under artificial infestation condition during *Kharif* 2016

Table 3: Correlation coefficient and regression equation between plant height and damage caused by *Chilo partellus.*

Damage symptoms	Correlation coefficient (r)
percent plant infestation	-0.348
Mean tunnel length	-0.439
Mean no. of exit holes	-0.514*
Mean leaf injury	-0.332

4. Conclusion

From the above discussion it is concluded that among the twenty germplasm tested for their reaction to *C. partellus*, the least percent infestation was recorded in genotype IIMRQPMH 1608 and highest in genotype IIMRQPMH 1604.With respect to the mean percent stem tunnelling, mean leaf injury score and mean tunnel length, the maize germplasm, IIMRQPMH 1608, FQH 106 and IIMRQPMH 1606, were found less susceptible. However, susceptibility to maize stem borer was reported more in germplasm IIMRQPMH 1604, IIMRQPMH 1610 and IIMRQPMH 1502.

Among all the germplasm tested, the effect of *Chilo partellus* infestation on plant height was less in germplasm IIMRQPMH 1508, FQH 106 and QPM-MH-27; whereas the germplasm IIMRQPMH 1604, IIMRQPMH 1501 and IMHQPM 1530 suffered more. The maize germplasm IIMRQPMH 1608, FQH 106 and IIMRQPMH 1606 were recorded less number of exit holes/plant; whereas IIMRQPMH 1604, IMHQPM 1530 and IIMRQPMH 1610 showed more number of exit holes/plant among all the tested germplasm. On the basis of plant height, it is inferred that the maize germplasm varied widely in their ability to withstand the pest injury.

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