ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 45(3): 293-301, September 2020

EXPLORATION OF SOURCES OF GENETIC RESISTANCE IN MAIZE GENOTYPES AGAINST STEM BORER (*Chilopartellus* (Swinhoe))

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Abstract

Fourteen different maize genotypes were screened for their relative resistance to maize stem borer *Chilopartellus* (Swinhoe) under glass house condition at National Maize Research Program, Rampur, Chitwan during two consecutive years 2018 and 2019. The design of the experiment was completely randomized design having 2 replications. The unit plot size was one row of one meter length with 50 cm row to row and 20 cm plant to plant spacing. Two second instar larva of *C. partellus* (Swinhoe) per plant were released two times, first at 8th leaves (vegetative) and second at 12th leaves (Before tasseling) stages. Insect damage parameters (IDPs) viz. dead heart percentage, damage % at vegetative and foliar stage, foliar injury rating (1-9) at vegetative and before tasseling stage, tunnel length (cm), exit hole number and yield per plot were recorded to study the germplasm susceptibility level. The result revealed that IDPs and yield varied significantly among the tested genotypes. Over the years, IDPs like dead heart percentage (5.17%), percent damage atpre-tasseling stage (10.6%), foliar injury level (2.25), tunnel length (10.15 cm) and exit holes (2.32) were found lower with high yield (2235 g/plot) in RML-95/ RML-96 followed by RML-86/RML-96. Two pipeline maize hybrids RML-95/RML-96 and RML-86/RML-96 with least damaged by maize stem borer in both years will be useful for maize stem borer resistance source.

Keywords: *Chilopartellus*, damage, host resistance, gemplasms, maize.

Introduction

Maize (*Zea mays L.*) is thesecond most important staple crop after rice in terms of area coverage (28%) and production (26%) and mainly grown by small holder rural farmers of Nepal (MoAD, 2018). Although maize is important for agriculture and livelihoods in Nepal, it has a low productivity of only 2.67 t/ha compared to its attainable yield of about 5.7 t/ha (MoAD, 2018; NMRP, 2017). The crop grows in a wide range of conditions relative to any other cereal and is thus susceptible to more hazards and is considered a high-risk crop than any other cereal crop. Multiple biotic and abiotic factors impede the production and productivity of maize. Among the major biotic constraints, *Chilopartellus* (Swinhoe) (Lepidoptera: Pyralidae) is the most damaging insect pest of maize in South Asia, including Nepal (Sharma and Gautam, 2010; Neupane and Subedi, 2019). It attacks maize plants in the whorl and tassel stages of growth. Severe

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attacks result in dead-hearts, causing around 15 to 20 percent loss of yield to the affected plant (CIMMYT, 2011). Climate change is likely to cause unexpected changes in the distribution, frequency and severity of pests at different locations in Nepal. Planting resistant varieties deliver one of the most effective and environmentally friendly control strategies for maize pests in Nepal. The development and use of insect resistant cultivars is non-polluting, stable and durable both across time and environments (Barzman*et al*., 2015). Resistant cultivars can also be successfully incorporated into an integrated pest management strategy(Wu and Baldwin, 2010). Breeding for host plant resistance, therefore, deserves major emphasis in maize improvement programs. Elite maize germplasms were screened to investigate the source of resistance against stem borer (*Chilopartellus* (Swinhoe)) under glass house condition at National Maize Research Program, Rampur, Chitwan, Nepal.

Materials and Methods

Fourteen maize genotypes were screened for relative resistance to maize stem borer under glass house conditions at National Maize Research Program, Rampur, Chitwan, Nepal for two consecutive years 2018 and 2019. The design of the experiment was completely randomized design having 2 replications. The unit plot size was one row of one meter length with 50 cm row to row and 20 cm plant to plant spacing.A total of 5 plants were maintained in each row where two plants were considered as border plants from both ends of the rows and remaining three plants were infested with *C. partellus* (Swinhoe). Two second instar larva of *C. partellus* per plant were released two times, first at 8^{th} leaves (vegetative) and second at 12^{th} leaves (before tasseling) stages. Each experiment plot as a unit was fertilized with a recommended dose of fertilizers 120:60:40 (N: P_20_5: K_20) kg/ha for Open Pollinated Varieties (OPVs) and 180:60:40 (N: P_20_5: K_20) kg/ha for hybrids. Insect damage parameters viz. dead heart percentage, damage % at vegetative and foliar stage, foliar injury rating (1-9) at vegetative and before tasseling stage (Tefera *et al*., 2011), tunnel length (cm), exit hole number and yield were recorded from the infested three plants of each rows, excluding border plants to test the germplasm susceptibility level. All data were analyzed statistically using MS-Excel and Genstat statistical software. Analysis of variance was done at 1 and 5% level of significance.

Results and Discussion

The analysis of variance revealed highly significant ($P < 0.01$) differences among the fourteen genotypes for stem borer damage parameters and yield except foliar injury level at vegetative and before tasseling stage under glasshouse condition at Rampur, Chitwan, Nepal during 2018 and 2019 (Table

1 and 2). It also showed within range of co-efficient of variation for all the recorded parameters. Among the screened genotypes, dead heart percentage varied 6.40 to 11.50% with the mean of 8.64 ± 0.27 during 2018 (Table 1) while it ranged 3.00 to 8.50% with the mean of 5.48 ± 0.27 during 2019 (Table 2). The percent damage on vegetative stage varied 21.83 to 37.89% while it ranged 2.65 to 6.75% at before tasseling stage with the mean of 28.79 ± 0.87 and 4.81 ± 0.20 respectively during 2018 (Table 1). During 2019, the mean percent damage on vegetative stage was 24.15 ± 0.96 ranged from 16.47 to 34.19% which was found from 1.35 to 5.65% before tasseling with the mean of 3.80 ± 0.19 (Table 2). The maximum foliar injury level (1-9) was recorded up to 6.35 and 4.15 with the mean of 4.04 ± 0.16 and 2.44 ±0.14 during 2018 and 2019 respectively. The average tunnel length of 14.61±0.47 cm ranged from 10.91- 20.20 cm during 2018 (Table 1) and mean tunnel length of 11.33±0.47 cm which ranged from 7.21- 16.50 cm was recorded during 2019 (Table 2). The number of exit holes were higher in 2018 as compared to 2019. The average count of exit holes was 4.61±0.36, ranged from 2.87 to 7.95 in 2018 (Table 1) while it varied from 1.45 to 6.95 with the mean count of 3.38±0.38 during 2019 (Table 2). The yield per plot was recorded higher during 2019 with the mean of 1088.74±100.56, ranged from 335.6 to 2612.5 g (Table 2). Similarly, the mean plot yield of 803.3±74.99, varied from 265.6 to 1952.2 g was recorded during 2018 (Table 1).

Table 1. Descriptive analysis of stem borer (*Chilopartellus* (Swinhoe)) damage parameters and yield on maize genotypes evaluated under glasshouse at Rampur, Chitwan Nepal during FY 2018

Parameters	Mean ± SEm	Range	F test	LSD (0.05)	CV (%)
Dead heart (%)	†8.64 ± 0.27	6.40–11.50	**	1.16	6.30
Damaged at VS (%)	28.79 ± 0.87	21.83 – 37.89	**	3.19	5.20
Damaged at BTS (%)	4.81 ± 0.20	2.65 – 6.75	**	1.92	4.50
Foliar injury level at VS (1-9)	20.01 ± 1.18	11.69–31.97	*	1.67	16.10
Foliar injury level at BTS (1-9)	4.04 ± 0.16	2.75 - 6.35	**	0.58	6.70
Tunnel length (cm)	14.61 ± 0.47	10.91–20.20	**	1.44	4.60
Exit hole	4.61 ± 0.36	2.87 – 7.95	**	0.42	4.30
Yield (g)	803.03 ± 74.99	265.6–1952.5	**	41.39	2.40

† Means of 2 replications, SEm- standard error mean, VS- vegetative stage, BTS- Before tasseling stage, Yld- Yield, %- percentage, cm- centimeter, g- gram, * and ** are significant at 5 and 1 % level of significance respectively.

Table 2. Descriptive analysis of stem borer (*Chilopartellus* (Swinhoe)) damage parameters and yield on maize genotypes evaluated under glasshouse at Rampur, Chitwan Nepal during FY 2019

Parameters	Mean ± SEm	Range	F test	LSD (0.05)	CV (%)
Dead heart (%)	†5.48 ± 0.27	3.00–8.50	**	1.13	9.50
Damaged at VS (%)	24.15 ± 0.96	16.47 – 34.19	**	2.71	5.20
Damaged at BTS (%)	3.80 ± 0.19	1.35 – 5.65	**	2.37	6.60
Foliar injury level at VS (1-9)	16.69 ± 1.16	9.39–29.07	NS	1.74	21.40
Foliar injury level at BTS (1-9)	2.44 ± 0.14	1.05 – 4.15	*	1.09	21.00
Tunnel length (cm)	11.33 ± 0.47	7.21–16.50	**	2.34	9.60
Exit hole	3.38 ± 0.38	1.45 – 6.95	**	0.78	10.70
Yield (g)	1088.74 ± 100.56	335.6–2612.5	**	92.14	3.90

† Means of 2 replications, SEm- standard error mean, VS- vegetative stage, BTS- Before tasseling stage, Yld- Yield, %- percentage, cm- centimeter, g- gram, NS- not significant, * and ** are significant at 5 and 1 % level of significance respectively.

The combined analysis over the years showed that both genotypes and year differed significantly with insect damage parameters and yield per plot (Table 3). Among the screened genotypes, over the years, the lower dead heart percentage (5.17%) was recorded in RML-95/ RML-96 followed by RML-86/RML-96 (5.75%) and ranged from 5.17 to 9.75%. The percent damage on vegetative stage varied from 19.25 to 35.03% while it ranged from 10.60 to 29.28% at before tasseling stage (Table 3). The percent damage on vegetative and before tasseling stage were 19.25 and 10.6 % in RML-95/ RML-96 followed by RML-86/RML-96 with 20.6% and 12.14% respectively. The foliar injury level ranged from 2.75 to 5.50 during vegetative stage while it was 2.25 to 4.75 at before tasseling stage. Relatively lower foliar injury level was recorded in RML-95/RML-96 i.e. 2.75 at vegetative stage and 2.25 in before tasseling stage followed by RML-86/RML-96 i.e. 3.25 at vegetative stage and 2.25 in before tasseling stage. The lower tunnel length (10.15 cm) was found in RML-95/RML-96 followed by RML-86/RML-96 (10.58 cm) which varied from 10.15 to 17.79 cm. The exit hole ranged from 2.32 to 7.30 and the lower number of exit hole (2.32) was found in RML-95/RML-96 followed by RML-86/RML-96 (2.44). Over the years, the highest plot yield (2235.00 g) was recorded in RML-95/RML-96 followed by RML-86/RML-96 (1147.15 g) and the yield varied from 312.80 to 2235.00 g/plot among the genotypes (Table 3)

Table 3. Combined mean performance of maize genotypes to the stem borer (*Chilopartellus* (Swinhoe))damage and yield components under glass house at NMRP, Rampur during 2018 and 2019

Genotypes	DH%	Damaged %		Foliar Injury Level (1-9)		TL (cm)	EH	Yld/Plot (g)
		VS	BTS	VS	BTS			
Poshilo Makai-1	6.48†	25.14	16.46	5.25	3.25	11.94	2.50	865.33
Poshilo Makai-2	6.26	23.20	14.31	3.75	3.00	11.01	2.95	934.30
Manakamana-7	7.37	28.30	16.93	5.00	3.25	14.00	3.94	1087.60
Deuti	6.50	21.00	22.20	4.00	3.00	12.50	2.90	898.00
BGBY-Pop	6.00	22.40	13.49	4.75	3.00	11.11	3.37	902.60
RML-86/RML-96	5.75	20.60	12.14	3.25	2.25	10.58	2.44	1147.15
RML-95/RML-96	5.17	19.25	10.60	2.75	2.25	10.15	2.32	2235.00
Rampur Hybrid-2	7.10	28.08	13.53	3.75	2.88	12.04	2.60	1032.20
Rampur Hybrid-4	6.50	25.70	14.35	4.00	3.00	11.83	2.45	991.50
Rampur Hybrid-6	7.00	29.29	16.14	3.75	2.75	11.20	2.69	1138.10
RML-86	9.00	32.66	24.65	5.00	4.00	15.87	7.30	966.75
RML-17	9.75	35.03	29.28	5.50	4.25	17.79	7.09	312.80
RML-95	7.74	29.39	23.73	4.00	3.68	14.88	6.55	373.80
RML-96	8.27	30.60	29.14	5.50	4.75	16.70	6.83	357.30
Grand mean	7.06	26.47	18.35	4.30	3.24	12.97	3.99	945.89
CV (%)	7.5	5.2	5.5	18.5	12.6	7.0	7.3	3.5

† Combined mean of two years, DH- dead heart, VS- vegetative stage, BTS- before tasseling stage, TL- tunnel length, EH- exit hole, Yld- Yield, %- percentage, cm- centimeter, g- gram, **- highly significant, NS- not significant

Relationship between foliar injury level at before tasseling stage (BTS) and yield per plot

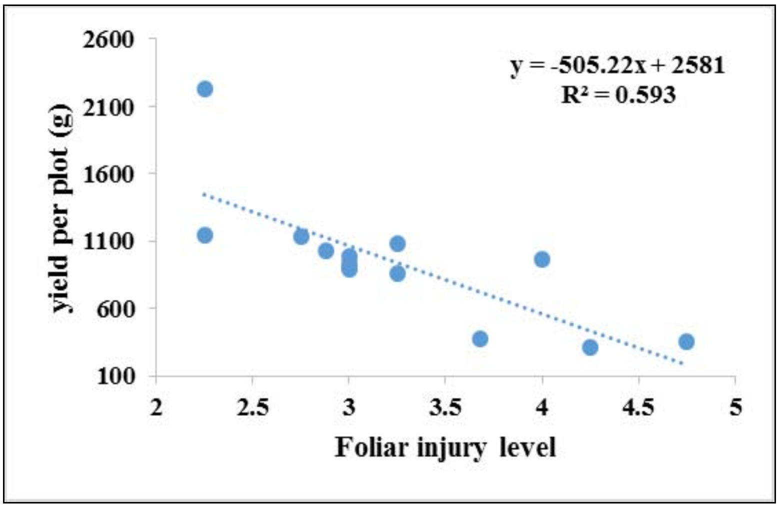

Figure 1. Relationship between foliar injury level at BTS and yield per plot (g).

The yield per plot was negatively correlated with foliar injury level at before tasseling stage which was linear, displayed downward and could be shown by equation Y = -505.22x + 2581, with regression coefficient R^2 = 0.59, where Y denoted predicted yield of maize and x stood for foliar injury level before tasseling stage (1-9 scale). The foliar injury level before tasseling stage explain 59% of the variance in the maize yield per plot under glasshouse experiment at NMRP, Rampur (Fig. 1).

Relationship between percent damage at BTS and tunnel length

In 2018-19, the percent damage at before tasseling stage showed positive correlation with tunnel length which was linear, displayed upward and exhibited the equation Y= 0.3679x + 6.2189, with regression coefficient R^2= 0.88 gave the best fit (Fig. 2) showing that increase in damage percentage at before tasseling stage, the tunnel length was also increased.

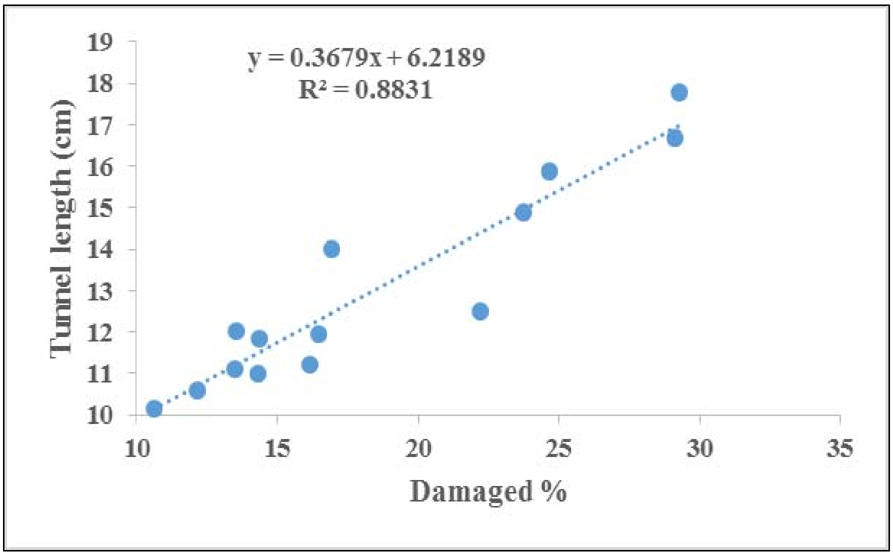

Figure 2. Relationship between percent damage at BTS and tunnel length.

Host plant resistance is the easiest and safest control method for maize stem borer, without use of pesticides.. It is a genetically coded trait that expresses itself as antibiosis, non-preference, tolerance or resistance by means of various mechanisms that suppress or disrupt the growth of the pest. The characteristic symptoms of *C. partellus* damage are the development of dead hearts and, most frequently, whorl feeding and tunneling within the stem resulting in a disruption of the flow of nutrients to the ear (Kfir *et al*., 2002). Stem borer resistant maize cultivar reduces yield losses, pesticide costs and related health risks. A number of experiments have been performed to test sources of resistance in maize genotypes against *C. partellus* (Swinhoe) at various locations (Kanta and Kaur, 2000; Khan and Monobrullah, 2003; Patel, 2005, Shahzad*et al*., 2006;Arabjafari and Jalali, 2007; Afzal*et al*.,2009; Ngongwa, 2011; Patel and Patel, 2012;Rajsekhar and Srivastav, 2013;Dindor *et al*., 2016;NMRP, 2017; Joshi *et al*., 2019). From this experiment, maize hybrids RML-95/RML-96 and RML-86/RML-96 have lower dead hearts, low foliar injury along with damage, low tunnel length, fewer exit holes and higher plot yields compared to other genotypes tested. The present findings are consistent with Joshi *et al*.(2019), which claimed that dead heart formation and leaf injury were higher in more susceptible genotypes than the least susceptible ones. Phenotypic aspects, including increased leaf fiber, silica, surface wax and high hemi cellulosic content, have been established as resistance mechanisms to stem borers (Bergvinson *et al*., 1995). The outcome of this studyis also in line with past research findings, which reported that the pipe line hybrids RML-95/RML-96 and RML-85/RML-96 were moderately resistant to *C. partellus* (NMRP, 2017).

Conclusion

Over the years, RML-95/RML-96 and RML-86/RML-96 have been identified as the two promising pipeline maize hybrids least affected by stem borer and showed highest degree of resistance among the genotypes under study.

Acknowledgements

Thanks to NMRP team for their valuable suggestions, continuous support and facilities during experimentation period.

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