Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.5164

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (4):** 1011-1021 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Study on Morphological and Biochemical Features Associated With Maize (*Zea mays* L.) Resistance Against *C. partellus*

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Received: 7.07.2017 | Revised: 16.07.2017 | Accepted: 17.07.2017

ABSTRACT

Four maize genotypes comprising two resistant (551-5 and 335) and two susceptible :295 and 1015 (2+3),were selected for studying mechanisms and bases of resistance. Under both choice and no choice conditions the observed lesser oviposition on resistant genotypes, in comparison to susceptible ones, indicated ovipositional antixenosis. Prolonged larval period, reduced larval and pupal survival, reduction in length and weight of larvae and pupae, lower growth index, adult longevity, fecundity and increase in total life span of maize stem borer constituted antibiosis effect of resistant genotypes. Nitrogen (r = -0.87), protein (r = -0.87), total sugars (r = -0.91) and phosphorus (r = -0.91) were negatively and significantly correlated with the total life span of maize stem borer. However, potassium (r = 0.92) and total phenols (r = 0.92) had positive and significant impact. Influence of nitrogen (r = 0.87), protein (r = 0.87), total sugars (r = 0.91), reducing sugars (r = 0.89) and phosphorus (r = -0.91) on per cent larvae completing life cycle was positive and significant. Potassium (r = -0.92) and total phenols (r = -0.92) exhibited negative and significant correlation with the per cent larvae completing life cycle. Avoidable grain yield losses to the tune of 22.27 and 42.41 per cent were observed due to maize stem borer in recommended hybrid HM-4 under unsprayed natural infestation and unsprayed artificially inoculated conditions, respectively. The application of recommended insecticide endosulfan resulted in 28.65 and 73.63 per cent increase in grain yield under sprayed natural infestation and sprayed artificially inoculated conditions, respectively.

Key words: *Antixenosis, Antibiosis, Chilo partellus, Morphological, Biochemical, Mechanism, Resistance*

INTRODUCTION

Maize (*Zea mays* L.), belonging to the family Graminae, is cultivated as an important cereal crop for human food, animal feed, fodder and 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 from sowing to harvest causing damage to root, stem, leaf, tassels, silk, grain/seed.

Cite this article: Lokesh and Mehla, J.C., Study on Morphological and Biochemical Features Associated With Maize (*Zea mays* L.) Resistance Against *C. partellus*, *Int. J. Pure App. Biosci.* **5(4):** 1011-1021 (2017). doi: http://dx.doi.org/10.18782/2320-7051.5164

Among these, *Chilo partellus* (Swinhoe) (Pyralidae: Lepidoptera) a key pest, commonly known as maize stem borer or spotted stem borer, damages the maize plant from 1-2 weeks old stage till harvesting resulting in serious yield losses[1,2]. Female moth lays eggs on the plant leaf lamina. Young larva causes damage to the plant, initially, by scrapping off chlorophyll in the leaf whorl and later on by feeding on the growing point. The third instar larva bores into the plant stem and starts tunneling. The fully mature larva pupates inside the plant tissue [3]. Severe attack of this pest results in stunted growth, dead hearts and stem breakage adversely affecting the crop yield.

Maize stem borer can be controlled by using various insecticides[4-6] . However, extensive use of insecticides is not a viable strategy as it directly increases the cost of cultivation and human health hazards in the food and drinking water. The indiscriminate use of insecticides also causes environmental pollution, ecological imbalance by killing non-target species, insecticidal resistance, pest resurgence and secondary pest outbreak. In view of the above problems associated with chemical control of pests, efforts are made to devise some cost-effective, eco-friendly and socially viable and acceptable technique for managing pests control

Though plant structures may influence negatively as well as positively on herbivorous and their natural enemies[7,8], yet certain morphological characters and biochemical composition of plant have been considered important in host plant resistance for *Chilo partellus* [9]. Earlier, Painter[10] had emphasized the need to identify sources of resistance in host plant to the target pests, followed by identification of physio-chemical factors involved in host-plant selection by the insects, both for oviposition and feeding [11]. Some morphological factors interfere with oviposition and feeding by the insects making them less suitable or unsuitable host. For instance, density of trichomes on the leaf surface of different maize cultivars has been reported to impart resistance against stem borer[12-14]. The resistant varieties of maize were reported to have distinctly more number of lignified vascular bundles as compared to susceptible varieties which obstructed the larval penetration into the stem[15].

Maize germplasm showing relative resistance to *C. partellus* have, earlier, been reported by several workers[16-19]. 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 [20,21]. Kumar[22] 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.

Quantitative estimation of some bio-chemical constituents indicated that polyphenol and potassium contents were significantly lower in highly susceptible genotypes and were negatively correlated with stem borer susceptibility while the phosphorous content was observed to have a positive correlation and moisture content did not share any relationship with the stem borer infestation[20]. Later on, they reported that there was no variation in free amino acid concentration among the genotypes, whereas, total sugars, reducing sugars and protein contents were positively correlated with stem borer susceptibility[23]. Rao and Panwar [21] did not notice any distinct difference in nitrogen, crude protein and moisture content in stem borer (*C. partellus)* resistant and susceptible varieties, at various stages of maize crop growth. However, they observed that less carotenoid content in early stages of crop growth contribute towards resistance against the stem borer in maize. As stable sources of resistance are not yet available, therefore, there is a need for the identification of more sources of resistance in Maize (*Zea mays* L.) against *C. partellus*. This paper reports the results of study carried out on some morphological and biochemical Traits associated with maize (*Zea mays* L.) resistance against *C. Partellus.*

MATERIALS AND METHODS

Materials

Four maize (*Zea mays* L.) germplasm comprising two resistant 551-1 and 335, and two susceptible 295 and 1015 (2+3) genotypes; Folin Ciocalteu's Phenol reagent, catechol, 2,4-dinitrophenol, vanamolybdic acid, micro flame photometer, microscope, colorimeter (Spectronic-20), pressure tester (OGAWA SEIKI Co. Ltd., Tokyo, Japan), Grinding Mill (Willey), micrometer(ocular).

Morphological Characteristics

Trichomes of Plant Leaf Surface

Trichomes, microscopic hairs on leaf surface, were determined as described elsewhere [12]. Ten leaves each of the selected maize genotypes were plucked from 10, 20 and 30 days old plants. Ten pieces of lamina, each with1 cm^2 area, from each leaf were excised and kept in FAA solution (5 mL formalin + 5ml acetic acid (glacial) + 90 ml 70 % ethyl alcohol) for seven days and then preserved in 70 per cent ethyl alcohol. Chlorophyl from leaf lamina pieces was removed first in 95 per cent ethyl alcohol at 60 ^{0}C folloewd by in concentrated lactic acid (90 %) at 85°C. Leaf pieces were then observed under microscope at 60X magnification. Number of trichomes was recorded at five randomly selected microscopic fields. Thus, 50 observations, for each genotype leaf, both on lower and upper surface, were made. Further, the lengths of trichomes at leaf lamina were recorded using an ocular micrometer at 60X magnification. .

Stem toughness

Stem toughness of selected maize plants were recorded using a pressure tester (OGAWA SEIKI Co. Ltd., Tokyo, Japan). The mean value of stem toughness was obtained from the average of the values recorded on its five randomly selected points.

Phytochemicals Analysis

Estimation of total phenols

Phenolic content of maize plant leaves was determined using a method due to Swain and Hillis [24]. The leaf samples collected from 10, 20, and 30 days old selected maize plants were kept at room temperature for 3 to 4 days and then were further oven dried at 80ºC. Dried leaf samples were ground using a Willey Grinding Mill and their methanolic extract was prepared using 80 % methanol.

One mL of methanolic extract of dried leaf powder, one mL Folin Ciocalteu's Phenol reagent solution and one mL saturated Na_2CO_3 solution were mixed and made to 25 mL using distilled water and kept for an hour. Transmittance of blue colored solution thus obtained was recorded at 725 nm on a colorimeter (Spectronic-20). Total phenol was determined from a standard curve prepared with catechol.

Determination of total sugars

Total sugars in plant leaves of selected maize zenotypes were determined following the method described by Dubois *et al.*[25]. One mL methanolic extract of plant leaf powder was diluted to 25 mL with distilled water. To one mL of the diluted extract, 2 mL of 2.5 per cent phenol and 5 mL conc. sulphuric acid were added and the volume was made to 25 mL with distilled water. Total sugars were determined by comparing the recorded absorbance, at 490 nm, on the standard curve prepared with glucose.

Determination of reducing and non-reducing sugars

Reducing sugars in plant leaves of selected maize zenotypes were estimated by the method due to Paleg[26]. Then, the non-reducing sugars was obtained by subtracting reducing sugars from total sugars.

Determination of Nitrogen, Proteins and phosphorus

The plant leaf powder (0.5 gm) was digested by heating with 10 mL mixture of sulphuric acid and perchloric acid (4:1) in 100 ml conical flask to get clear colourless solution and the volume was made to 50 mL using distilled water. Using this solution, percent nitrogen was determined by Microkjeldahls method[27]. The nitrogen percentage was then multiplied by 6.25 to get protein percentage.

Phosphorus content of plant leaf was determined following the procedure outlined by Jackson[28]. To five mL plant leaf digested solution, obtained above, two drops of 2,4-dinitrophenol was added. To this ammonium hydroxide was added, dropwise, with continuous stirring till yellow colour appeared. Then 6N HCl was slowly added to decolorize the solution. Five mL vanamolybdic acid was then added and final volume was made to 25 ml with distilled water. Intensity of yellow colour was read at 440 nm on Spectronic-20.

Determination of Potassium

Potassium was determined following the method due to Richards [29]. Five mL plant leaf extract was diluted to 50 mL with distilled water. Absorption was recorded on micro flame photometer, pre-standardized with the standard KCl aqueous solutions.

RESULTS AND DISCUSSION

Biophysical characteristics of maize genotypes

Density and Size of trichomes

Four genotypes comprising of two resistant (551-1 and 335) and two susceptible [295 and 1015 (2+3)] were selected for studying mechanisms and bases of resistance. Density of Trichomes at upper and lower leaf laminas of selected maize genotypes at 10, 20 and 30 days after emergence are given in table-1. For each studied maize genotypes density of trichomes at upper leaf lamina is higher than at the corresponding lower leaf lamina and the density increases with the plant age over the studied period. Trichomes density on upper as well as lower laminas varies in the order:[551-1] > [335] > [1015 (2+3)] > [295]. The trichome density at upper and lower leaf lamina of resistant genotypes: 551-5 and 335, were significantly higher than for susceptible genotypes: 295 and 1015 (2+3) at 10, 20 and 30 days. Therefore, it can be inferred that high trichome density of leaves of resistant genotypes could be responsible for inhibition of oviposition by the moths. It is also evident from the observed data on egg mass or number of eggs per plant given in table-2. Both these parameters are significantly lower in studied resistant maize genotypes compared to those of corresponding susceptible genotypes in choice as well as no choice condition. The trichome density on lower leaf lamina in all the genotypes was almost half of the trichome density on the respective upper leaf lamina, indicating that the moths preferred to lay eggs on the lower leaf lamina. The observed higher number of eggs at lower leaf surface conforms with the reports of Durbey and Sarup[12]. According to them, moths may prefer the lower leaf lamina for oviposition to protect the eggs from desiccation due to excess heat, thus, providing better chances of their survival.

Table 1: Trichome density (per microscopic field at 60X magnification) on upper and lower leaf lamina of selected maize genotypes at different days after emergence (DAE) of plant

Genotype	Upper leaf lamina			Lower leaf lamina		
	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE
551-1	2.54**	5.55	9.42	0.84	2.32	4.44
335	1.96	3.95	6.45	0.66	2.21	4.32
295	1.54	2.97	5.58	0.40	1.03	2.85
1015 (2+3)	1.68	3.04	5.76	0.58	1.10	2.78
S.E.(mean)	0.15	0.35	0.61	0.53	0.15	0.8
C.D.(p=0.05)	0.47	1.63	2.01	0.15	0.51	0.28
C.V. (%)	16.11	13.68	12.48	15.41	14.94	13.47

Table 2: Oviposition (egg mass and number of eggs per plant) of *C. partellus* on selected maize genotypes

Genotype	Egg mass/plant		Number of eggs/plant	
	Choice conditions	No choice conditions	Choice conditions	No choice conditions
551-1	0.5	1.1	8.6	13.8
335	1.1	1.2	11.7	16.7
295	2.7	1.5	30.3	26.4
1015 (2+3)	2.6	1.5	25.2	20.7
S.E.(mean)	0.1	0.1	1.2	0.6
C.D. (p=0.05)	0.3	0.2	4.3	2.3
C.V. (%)	11.6	12.2	10.7	9.3

Length of Trichomes at upper and lower leaf laminas of selected maize genotypes at 10, 20 and 30 days after emergence are given in table-3. It was observed that differences in trichome length among studied genotypes of maize was non-significant at their specified number of days after emergence on the upper as well as lower lamina. However, the length of tricomes on the upper lamina are less than at lower lamina, irrespective of the age of the plant over the studied period. It may be due to higher density of trichomes at the former that may be hindering the growth of trichomes on the upper lamina.

Table 3: Trichome length (in mm) on upper and lower leaf lamina of selected maize genotypes at different days after emergence (DAE)

Genotype	Upper leaf lamina			Lower leaf lamina		
	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE
551-1	0.17	0.32	0.48	0.24	0.44	0.70
335	0.21	0.38	0.54	0.21	0.39	0.64
295	0.19	0.39	0.51	0.26	0.49	0.75
1015 (2+3)	0.18	0.35	0.51	0.25	0.47	0.71
S.E.(mean)	0.02	0.03	0.04	0.04	0.04	0.06
C.D.(p=0.05)	NS*	NS	NS	NS	NS	NS
C.V. (%)	15.06	12.09	13.88	11.59	15.48	13.76

*NS = Non-significant

Stem toughness

Stem toughness at different days after emergence (DAE) of selected maize genotypes are recorded in table 4. It is observed that stem toughness for all the studied genotypes at the given age, over the study period, was statistically similar,

Table 4: Stem toughness (kg/cm^2) of selected maize genotypes at different days after emergence(DAE)

Maize Genotype	10 DAE	20 DAE	30 DAE
551-1	0.94	2.36	3.98
335	0.96	2.14	3.44
295	0.92	2.81	3.74
1015 (2+3)	0.84	2.65	3.52
S.E. (mean)	0.08	0.22	0.33
C.D.(p=0.05)	NS*	NS	NS
C.V. (%)	15.00	16.90	13.22

*NS = Non-significant.

Biochemical characteristics of maize genotypes

In order to assess the effect of biochemical factors on the biology of maize stem borer, levels of different biochemical constituents *viz*., nitrogen, potassium, proteins,, sugars, phenols, phosphorus and lignin in plant leaves of selected resistant and susceptible maize genotypes were determined. A perusal of the data presented in table-5, shows that, whereas, plant leaf nitrogen and proteins contents of resistant maize genotypes (551-1 and 335) are lower compared to those of susceptible ones [295 and 1015 (2+3)] at 10, 20 and 30 days of emergence of plant. However, the above plant leaf constituents, invariably, decrease with the increasing plant age in case of all the studied maize genotypes. Earlier, Kalode and Pant[30] and Sharma and Chatterji[31] had also reported that the maize germplasm which proved resistant in the field had comparatively less nitrogen. Further, Kabre and Ghorapde[23] observed positive correlation between protein content and susceptibility of maize varieties to the stem borer. However, Rao and Panwar[21] did not find any difference in the nitrogen and protein contents of resistant and susceptible genotypes of maize. Further, our observed higher potassium contents in resistant maize genotypes in comparison to the susceptible ones is in line with the work reported by Kabre and Ghorpade[20] who had found that the resistance in maize genotypes is associated with higher concentration of potassium. However, on the contrary, Sharma and Chatterji[31] had reported that plants of resistant genotypes of maize have lower potassium content as compared to susceptible ones.

Table 5: Nitrogen, proteins and potassium contents in plant leaves of selected Maize genotypes at their different days after emergence (DAE)

Genotype	Nitrogen (%)			Protein (%)			Potassium (%)		
	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE
551-1	2.11	1.75	1.24	13.18	11.13	7.75	1.52	1.43	1.21
335	2.07	1.62	1.17	12.93	10.13	7.31	1.49	1.37	1.18
295	2.34	2.16	1.75	14.62	13.50	10.93	1.30	1.09	0.96
1015 (2+3)	2.35	2.21	1.69	14.68	13.81	10.36	1.27	1.05	0.94
S.E. (mean)	0.19	0.10	0.08	1.21	3.27	0.78	0.12	0.10	0.07
C.D.(p=0.05)	NS	0.34	0.26	NS	0.98	2.59	NS	0.30	0.22
C.V. (%)	5.36	6.34	4.28	7.36	4.18	5.65	4.78	7.59	6.87

*NS = Non-significant.

Total sugars, reducing sugars and non-reducing sugars in plant leaves of selected maize genotypes are recorded in table-6. The sugar contents of resistant genotypes were found to be lower as compared to susceptible ones. The observed lowest(5.08%) and highest (7.10 %) being in resistant genotype and 551-1 and susceptible genotype, respectively.1015 (2+3), respectively. The above three types of sugars, invariably, increase with the increasing days after emergence (DAE). Our observed higher levels of sugars in resistant genotypes are in line with those of Kabre & Ghorpade [23] and Sharma and Chatterji[31] who had reported better survival of stem borer on maize varieties having higher concentration of sugar.

Table 6: Total sugars, reducing sugars and non-reducing sugars in plants of selected maize genotypes

Genotype	Total sugars (%)			Reducing sugars (%)			Non-reducing sugars (%)		
	10 DAE*	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE
551-1	5.08	6.14	7.88	3.56	4.39	5.35	1.52	1.75	2.53
335	5.97	6.88	8.06	4.05	4.68	5.52	1.92	2.20	2.54
295	7.24	9.82	11.87	5.10	6.74	8.50	2.14	3.08	3.37
1015 (2+3)	7.10	9.35	10.92	4.75	6.18	7.24	2.35	3.17	3.68
S.E. (mean)	0.56	0.71	0.86	0.39	0.49	0.59	0.18	0.22	0.27
C.D.(p=0.05)	NS	2.35	2.84	NS	1.61	1.95	0.59	0.74	0.89
C.V. (%)	7.25	6.35	8.58	4.15	6.68	7.49	5.36	4.59	5.52

NS = Non-significant
*DAE = Days after emergence of plants

The resistant maize genotypes (551-5 and 335) contained higher concentration of total phenols than susceptible genotypes [295 and 1015 (2+3)] in 10, 20 and 30 days old plants. Whereas, highest total phenol level (2.84%) was observed in the resistant genotype, 335, the lowest total phenolic level (1.84%) was in the susceptible genotype 1015 (2+3). The observed higher level of phenols in resistant maize genotypes compared to the susceptible ones is supported by the reported work of Kabre and Ghorpade[20] who had concluded that the resistance in maize genotypes is associated with higher concentration of phenols. Recently, Rasool et al.[32] have also reported higher phenolic content (antibiosis) in resistant genotypes CM-123 and CM-133 than in susceptible genotype Basi-local.

Further, total sugar levels in plant leaves for the four studied maize genotypes, invariably, decreased with the increase in the age of plants. Further, Phosphorus contents of resistant genotypes (551-5 and 335) are lower compared to the suscepticles genotypes [295 and 1015 (2+3)] with ones and decrease with the age of the plant. Sharma and Chatterji[31] and Kabre and Ghorpade[20], from their investigations, had also reported lower concentration of Phosphorus in resistant genotypes of maize.

Lignin contents of resistant maize genotypes 551-5 and 335 are higher compared to the susceptible genotype 295 (table 7). However, the other susceptible genotype 1015 (2+3) has lignin concentration nearly similar as for the resistant genotypes. Further, it is also observed that lignin level of each studied genotype, invariably, increases with the plant age. Higher level of lignin in resistant genotypes contributes more towards the hardness of plant stem thus obstructing the larval penetration[15]. The above observations reveal that both nutritional and anti-nutritional factors are important for overall susceptibility of hosts to insects.

Table 7: Total phenols, phosphorus and lignin contents in plant leaves of selected Maize genotypes at their different days after emergence (DAE)

Genotype	Total phenols (%)			Phosphorus (%)			Lignin (%)		
	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE
551-1	2.57	2.34	1.96	0.80	0.72	0.68	6.60	6.92	7.04
335	2.84	2.53	2.02	0.76	0.65	0.61	5.44	5.93	6.22
295	1.96	1.72	1.42	1.07	0.92	0.85	4.51	4.87	5.43
1015 (2+3)	1.84	1.64	1.38	1.15	0.99	0.90	6.00	6.23	6.89
S.E. (mean)	0.20	0.18	0.15	0.08	0.07	0.07	0.50	0.53	0.56
C.D.(p=0.05)	0.63	0.60	0.49	0.28	0.23	0.22	*NS	NS	NS
C.V. (%)	5.68	8.12	6.22	6.89	7.29	4.27	5.65	6.36	5.98

*NS = Non-significant

Influence of biochemical traits of maize genotypes on stem borer

Impacts of various biochemical traits of different maize genotypes on total life span and per cent larvae of stem borer completing life cycle are recorded in Table 8. It was observed that nitrogen (r = -0.87), proteins (r = - 0.87), total sugars (r = -0.91) and phosphorus (r = - 0.91) were negatively and significantly correlated with the total life span of maize stem borer. However, the impact of potassium (r = 0.92) and total phenols (r = 0.92) was positive and significant. Influence of reducing sugars, non-reducing sugars and lignin content was non-significant. Further, the impact of nitrogen (r = 0.87), proteins (r = 0.87), total sugars (r = 0.91), reducing sugars (r = 0.89) and phosphorus (r = 0.91) on per cent larvae completing life cycle was positive and significant. Whereas, potassium (r = -0.92) and total phenols (r = -0.92) exhibited negative and significant correlation with per cent larvae completing life cycle.

Table 8: Association of total life span and per cent larvae of *C. partellus* completing life cycle with biochemical traits of maize genotypes

Biochemical trait	Total life span	Per cent larvae completing life cycle
Nitrogen	-0.87**	0.87**
Protein	-0.87**	0.87**
Potassium	0.92*	-0.92*
Total sugars	-0.91*	0.91*
Reducing sugars	-0.88	0.89*
Non-reducing sugars	-0.87	0.86
Total phenols	0.92**	-0.92**
Phosphorus	-0.91*	0.91*
Lignin	-0.44	-0.47

* Significant at 5 per cent level, ** Significant at 1 per cent level.

Determination of avoidable losses due to maize stem borer

For determining avoidable losses due to stem borer infection in maize, experiment was conducted in randomized block design adopting the following treatments: (a) Unsprayed natural infestation (b) Unsprayed artificial infestation (c) Sprayed natural infestation and (d) Sprayed artificial infestation. Leaf injury score, percent dead hearts, plant height and grain yield per plant for maize hybrid HM-4 infested with stem borer (*C. partellus,* under different treatments, are recorded in table-9. It is observed that these parameters varied significantly among different treatments. The leaf injury rating was observed to be minimum in sprayed natural infestation conditions (3.97) and maximum in unsprayed artificially infested conditions (6.95). Per cent dead hearts varied from 6.85 in sprayed natural infestation conditions to as high as 30.44 in unsprayed artificially infested conditions. Likewise, average plant height was maximum in sprayed natural infestation conditions (171.10 cm) and minimum in unsprayed artificially infested conditions (106.04 cm).

Further, the grain yield was adversely affected by *C. partellus* infestation. In sprayed natural infestation conditions avoidable loss was 22.27 per cent while in sprayed artificially inoculated conditions the avoidable loss was 42.41 per cent. Earlier, reported avoidable losses in maize due to stem borer infestation, under varying agro-climatic conditions were: 20 to 87 per cent (Mathur)[5], 5.14 to 91.22 per cent (Singh and Sajjan)[33] and 50.3 per cent (Sharma and Sharma)[34]. The maize crop treated with insecticide (endosulfan) exhibited increase in grain yield by 28.65 and 73.63 per cent in natural infestation and artificially inoculated conditions, respectively.

Table 9: Damage caused by *C. partellus* in maize hybrid, HM-4 under different treatments

Treatment		Leaf injury score	Per cent dead hearts	Plant height (cm)	Grain yield (gm/plant)	Per cent avoidable loss	Per cent increase in yield due to insecticidal spray
Unsprayed	Natural infestation	5.08	18.74 (25.60)*	152.37	118.43	--	--
	Artificial infestation	6.95	30.44 (33.44)	106.44	60.63	--	--
Sprayed	Natural infestation	3.97	6.85 (16.25)	171.10	152.37	22.27	28.65
	Artificially infestation	4.72	15.68 (23.28)	152.47	105.27	42.41	73.63
S.E. (mean)		0.17	(0.54)	3.08	3.30	--	--
C.D. (p=0.05)		0.43	1.89	10.89	11.07	--	--
C.V. (%)		4.15	6.48	8.46	9.25	--	--

*Figures in parentheses are angular transformations

CONCLUSION

Studies on mechanism and basis of resistance on some selected maize genotypes revealed that there is lesser oviposition on resistant genotypes compared to susceptible ones indicating ovipositional antixenosis. Nitrogen, protein, total sugars, reducing sugars and phosphorus were negatively and significantly correlated with total life span of *C. partellus,* while the impact of potassium and total phenols was positively significant. The influence of nitrogen, protein, total sugars, reducing sugars and phosphorus on per cent larvae completing life cycle was positively significant. Whereas, potassium and total phenols manifested significantly negative correlations with per cent larvae completing life cycle. The grain yield was adversely affected by *C. partellus* infestation. A higher grain yield loss was observed under artificially inoculated conditions than during natural infestation.The maize crop treated with insecticide (endosulfan) exhibited increase in grain yield by 28.65 and 73.63 per cent in natural infestation and artificially inoculated conditions, respectively.

Acknowledgement

Authors are thankful to Dr. Sain Dass, the then Project Director, Directorate of Maize Research, New Delhi for providing seeds and other research facilities and also his fruitful discussion during the course of research work.

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