International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 24-06-2021, Accepted: 10-07-2021, Published: 24-07-2021
Volume 6, Issue 4, 2021, Page No. 64-69

Evaluation of host plant resistance traits in certain genotypes of maize (*Zea mays* l.) against maize spotted stem borer (*Chilopartellus* swinhoe, Crambidae)

Manish K Yadav[1], Lipsa Dash[1], Sandeep Rout[2]
[1] M.S. Swaminathan School of Agriculture Science, Centurion University of Technology and Management, Gajapati, Odisha, India
[2] Faculty of Agriculture, Sri Sri University, Cuttack, Odisha, India

Abstract
Host plant Resistance always been among the most sustainable and eco-friendly insect-pests management tactics. The beauty of Host Plant Resistance lies in its ability to manage pests in very unique way and allowing to be incorporated with other quick action techniques of pest management. In the curiosity of finding morphological traits associated with susceptibility levels, an experiment has been conducted with a total number of 25 evolutionary and highly adopted maize genotypes for evaluating their traits related to insect resistance. Genotypes namely hybrids *viz*., Shaktiman-1, Shaktiman-2, Shaktiman-3, Shaktiman-4, Shaktiman-5, RHM-1, RHM-2, RHM-3, P-3535, P-3533, P-3550, P-3555, Dekalb-9188, Dekalb-9170, composite namely Devaki, Laxmi, Suwan, Deep Jwala and promising genotypes namely New Cross 76×11, New Cross 72×70, New Cross 73×11, New Cross 73×74, New Cross 52×65, New Cross 53×52 and New Cross 50×58 were assessed for their morphological attributes against *Chilopartellus*. Among all the tested attributes, the maximum correlation with infestation was recorded in Plant Height (-0.797) followed by Leaf Angle (-0.676), Trichome Length (0.498) and Trichome Density (-0.451). These attributes of maize were found significantly associated with infestation levels of *Chilopartellus* and considered to be the infestation governing factors in maize genotypes for the given test insect.

Keywords: HPR, resistance, maize, stem-borer, insect-resistance, morphology

Introduction

India is an agriculture-based economy, having an average of 140 per cent cropping intensity which includes many groups of crops like cereals, pulses, oilseeds, fodders, vegetables and many others. Maize is the most important and second most widely grown cereal after rice. The origin place of maize or corn is Mexico and firstly domesticated about 10000 years ago by indigenous people of Mexico (Benz, 1999) [6]. It is also believed to have originated in Northern Guatemala (Weatherwax, 1955) [20]. Maize is a species of family Poaceae (tribe Maydeae), botanically known as *Zea mays* and firstly described by Carl Linnaeus (Franklin *et. al.*, 2013) [11]. Maize is a diploid (2n=20) and cross pollinated (monoecious) crop. The leafy stalk of the plant produces pollen inflorescences and separate ovuliferous inflorescences called ears that yield kernels or seeds, which are fruits of maize. Maize is very rich in nutrients like proteins, minerals & vitamins and termed as queen of cereals due to having highest genetic potential for yield. The plant of maize grows straight up to 2.5 meter, unbranched and having leaves on every node.

Maize is grown for many purposes including grains for food, for vegetable and for animals feed and fodders (Kakar *et. al*., 2003) [12]. It is well-known for its role as food, feed and industrial crop in Indian subcontinent and other divisions of the new as well as old world. It is also being used for production of alcohol-based drinks, sweetener agents for food commodities, starch, oil and different proteins. Recently, it was recently has been came into light that sweet corn can also be used in the production of industrial-fuels. A Healthy plant of maize can constitute about 60 to 68 per cent of carbohydrate and 7 to 15 per cent of amino compounds. The edible embryo part which forms about 12 per cent share of the whole grain is the source of different nutrients like protein, fats and sugar. Yellow part of maize is known to be the richest sources of Vitamin-A. Maize has more riboflavin than wheat or rice and is rich in phosphorous and potassium. About 50 per cent of the total Indian produce is consumed as poultry feed and about 8 per cent is consumed by the starch industry. The sweet corn has 1.2 to 5.7 per cent of edible type of oils. Maize oil is more commonly being used as a cooking medium and for manufacturing of different hydrogenated oils. Maize serves as a source in the manufacture of different biochemicals like starch, syrup, dextrose, oil, gelatine, lactic acid etc. Maize flour can be used as a thickening substance in the preparation of many edibles' items like soups, sauces and sweet custard powder. "Corn syrup is used as an agent in confectionary units. Corn sugar (dextrose) is used in pharmaceutical formulations as sweetening agent". "The gel of corn on account of its moisture retention character is used as a bonding agent for ice-cream cones, as a dry dusting agent for baking products according to Arnon, 2010". Maize in India is used as a source of poultry food (43%), human feed (23%), cattle feed (17%), starch industry (14%), brewery (2%) and seed (1%). It is extremely important for human and animal nutrition as staple food in a number of developed and developing countries. Maize consumption in India has grown up to 19 million tonnes (Anonymous, 2019) [3].

The word maize means "one that sustains life" and also an Indian legend says that maize was the food of the Gods that created the earth. Potentially, maize cultivation is gaining importance in Bihar due to increasing demand as animal feed, poultry and fodder and raw material for industries. It is cultivated throughout the year in most of the country for various purposes including grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn and industrial products. The production of maize crop by small holder farmers plays a vital role in alleviating poverty, income generation and contributing to the local and national economy. India ranks 5th in area, 8th in production and 15th in productivity of maize in world scenario. There is no other cereal crop which has such immense productivity potential as maize and therefore maize occupies the unique place as "Queen of Cereals" and "Miracle crop". Maize can be grown successfully in variety of soils ranging from loamy sand to clay loam.

There are many causes behind the low productivity of Maize in India like very less mechanization, use of indigenous seeds, using old tactics of crop production as well as protection and insect-pests (including diseases, weeds and damaging insects) (Ali *et al.,* 2015) [2]. In all the above-mentioned threats, insects-pests alone can cause huge damage up to 80 per cent to the crop during both the seasons (Rahman, 1994) [17]. There are several pests reported to be causing damage to the maize crop on different crop stages in which Corn Ear Worm, *Helicoverpazea*, *H.armigera*, Fall Armyworm, *Spodoptera frugiperda*, Spotted Stem Borer, *Chilopartellus*, Corn Plant Hopper, *Ricania* sp., Corn Aphid, *Rhopalosiphummaidis* and Cut Worm, *Agrotis* sp. are major and found to be causing huge loss to the crop (Mathur, 1992) [15]. Noticeably, certain pests are specific to a few sets of climatic conditions, the Maize Spotted stem borer is one of them which can affect crop on high relative humidity and temperature and mostly affect the crop during the *Kharif.*

There are fixed limitations under the possibility of increase in the area for this crop, the productivity of maize is also considerably low which may be due to several known as well as unknown reasons. One of the important constraints responsible for low productivity is undoubtedly the attack of various insect pests particularly the stem borers and cob caterpillars which have gained major economic importance. "The scenario with respect to insect pests of this crop has changed a lot in the recent past owing to increased area under single cross hybrids and mono cropping practiced by the farmers using indiscriminate quantity of chemical fertilizers". To improve and increase the information on the insect pests of maize in India, in general and Bihar, in particular except for some stray reports on the incidence and plant resistance of the major insects like, *Helicoverpa armigera* (Hubner), *Mythimna separata* (Walker), *Rhopalosi phummaidis* (Fitch), *Chilopartellus* (Swinhoe) and *Atherigona soccata* (Rondani).

Maize Spotted Stem Borer, *Chilopartellus* is a major pest of *Kharif* maize and found to be infesting the crop from mid of July to end of September and later they go to hibernate inside the stem in larval stages during the end of the *Kharif* maize. The insect, *Chilopartellus* belongs to family Crambidae subfamily Crambinae of order Lepidoptera. The larval stage of the maize spotted stem borer is responsible for causing damage in many crops including maize. The pest appears during *Kharif* in both tropics and sub-tropical zones. Typical damage symptoms include pinholes, shot holes and window on leaves, dead-hearts and exit-holes and dwarfing while internal symptoms include stem tunnelling (Kumar and Saxena, 1992) [14]. A typical maize plant has many characters to deter infestation of insects-pests including different kind of variations in height, stem thickness, leaves structure and area etc. These characteristics known to be deterring infestation independently of by the combination of various other characters or certain sets of environments (Kumar *et al.*, 2012) [13].

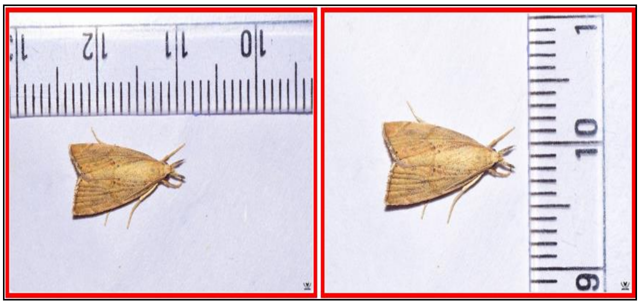

Plate 1 and 2: Maize Spotted Stem Borer, *Chilopartellus* Adult Moth

Physical or Morphological characters are prime to be identified during the course of evolution of host plant resistance tactics. In maize plants, morphological traits like plant height, stem thickness, internode lengths, number of nodes, trichome density and trichome lengths in a plant have been considered to be impacting on infestation and survival of maize spotted stem borer, *Chilopartellus.* Thesemorphological characters are inheritable and showed by genotypes in different degree of variations according to the set of environmental conditions on a particular area. Morphological characters are results of several years evolutionary interaction, done between the plant and particular insects and plant develop these characters in order to save themselves from excess injury of these pests. As an example, plants having more density of trichomes, showed very less evasion of insect-pests while smooth surfaces attract insects for egg laying as well as infestation. Excess and broad leaves play role in increasing canopy temperature as well as help larval movement from plant to plant while for natural egg laying, they provide more surface area. Morphological variation were primary sources of resistance with greater influence in pest management by inhibiting pest population to set on them. Characters like plant height, thickness and number of nodes are of prime importance and play vital role in infestation management.

Materials and Methods

The present study has been conducted in the years 2018 and replicated to confirm the findings in the year 2019 at Research Farm, RPCAU, Pusa in the cropping season of *Kharif* with the aim of finding resistant genotypes and factors including morphological, biochemicals and genotypic against Maize Spotted Stem Borer, *Chilopartellus* (Swinhoe). For the assessment of all the morphological charactersand artificial infestation, the crop was grown in the *Kharif* as the test insect *i.e.*, Maize Spotted Stem Borer, *Chilopartellus* infests maize crop during *Kharif* only (Uttam *et al.*,2017; Chavan *et al*., 2006) [19, 8]. The pest requires a hot and humid climate to complete its life cycle and *Kharif* is favourable for it.

After the artificial infestation, the following data have been taken from the crop:

Plant height is a major factor affecting the infestation of Maize Spotted Stem Borer, *Chilopartellus.* Plat height has significant effect on pest infestation specially in case of stem borers. In many cases, it has been observed that more infestation of Maize Spotted Stem Borer, *Chilopartellus*can decrease the plant height upto a significant level while height (as a morphological trait) and infestation showed a negative association. For plant height, a total number of 5 plants from each replication of each treatment have been selected and measured by meter scale (wooden meter scale).

Plant stem thickness was varying in all genotypes from local population, hybrid to promising genotypes. Stem thickness has very much importance in the aspect of infestation done by Maize Spotted Stem Borer, *Chilopartellus*as the pest mainly feeds on stem content and pupate inside the stem. For the estimation of stem thickness, a total number of 5 plants were selected from each replication of each treatment and measured with help measuring tape at three points of height *viz.* 3rd, 4th and 5th internode. Genotypes with a greater number of nodes showing comparatively less infestation against Maize Spotted Stem Borer, *Chilopartellus* as the insect mainly feeds inside the stem after entering through the whorl. For the assessment of total number of nodes, a total 5 plants were selected from each replication of each treatment and the node numbers were counted from lower first node up to the apex.

As Maize Spotted Stem Borer, *Chilopartellus* is a well-known pest feeding inside the stem or on the content of stem. The internodes may provide a warier and can stop the movement of Maize Spotted Stem Borer, *Chilopartellus* from one node to other. The feeding inside a single node can results in less infestation as well as deterring the ability of an adult moths to develop properly and to flight and mate while larger nodes can lead to provide more stem content to feed upon. For the estimating the length of internodes (distance between one node to other) had been assessed with the help of measuring scale by randomly selecting 5 plants from each replication of each treatment in all the genotypes.

Trichomes are hairy outgrowth of plant leaf and stem surface that may alter the insect orientation, egg laying, feeding as well as crawling on the plant surface. In maize, mostly trichomes are distributed over the upper surface of leaves in some non-specific patterns. For the assessment of trichome number, patches of 1 cm^2 have been selected from three locations of a leaf and isolated with the help of surgery blade. The total numbers of trichomes were counted with the help of 10× magnification glass (hand lens).

For trichome length, a total number of 5 plants were selected from each replication of each treatment and 3rd and 4th leaves have been taken for assessment. For trichome length, trichomes were extracted out from three paces of a leaf, apical leave, proximal end and middle of the leaf. For extraction, leaves chlorophyll was erased with the help of organic solvents like Di Methyl Sulpho-oxide and Ethanol by heating leaves in organic solvent for 12 hours at 60 ^{0}C in BOD. Later on, the trichomes were extracted with help of fine forceps, needles and surgical blades. For the assessment leaf orientation and leaf angle, a total number of five plants have been selected and data have been taken. Leaf width and length was recorded of 3rd and 4th leaf of each selected plant (5 plants) in all the replications. For the leaf angle, protactor was used after cutting the plant and the measurement of the angle was taken by placing protactor and angle between stem and leaves has been recorded.

The data of Infestation have been recorded from all genotypes after the artificial infestation of the crop.

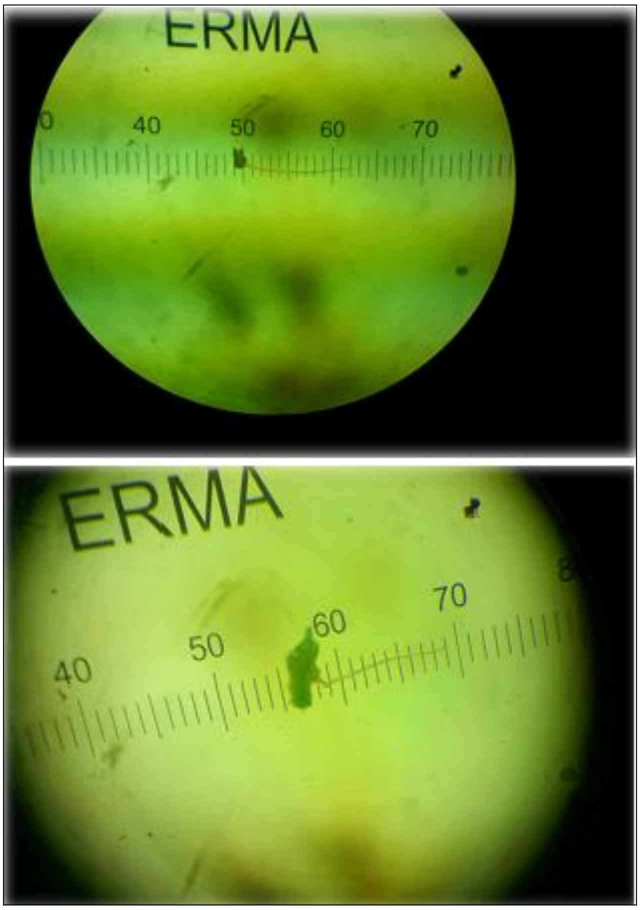

Plate 3 and 4: Trichome length under the measuring Binocular

Plate 5: Field View of Crop

Results and Discussion

The data Presented in table 1.showing various morphological parameters associated with various susceptibility levels of *Chilopartellus*.

Plant height

The height was ranged from 103.25 cm to 160.50 cm in which maximum height was recorded in P-3535 with 160.50 cm followed by New Cross (72×70) with 154.50 cm and RHM-3 with 152.50 cm of average height. Minimum height was recorded in genotype namely RHM-2 with 103.25 cm followed by Shaktiman-5 with 106.50 and P-3550 with 107.00 cm of average height. The average height in resistant check was 128.13 cm. Genotypes namely, New Cross 76×11, 58.00; RHM-1, 59.50 and Dekalb-9170 with 60.00

cm were found at par among each other while RHM-3, Deep Jwala, New Cross (73×11), New Cross (73×74) and New Cross (52×65) were found superior to check, Lakshmi (128.13 cm) and genotypes namely, P- 3533 with 134.50 cm; New Cross 53×52 with 134.50 cm and Shaktiman-4 with 135.50 cm were not found at par with resistantgenotype. Somewhat similar findings have been concluded in the studies of Afzal *et al*. 2009 [1]; Munyiri *et al*. 2012 and Dalin *et al*. 2008 [9] and they have concluded that genotypes having height between 122.50 to 130.00 cm, fall under the resistant category in the experiments on morphological parameters of plants and their association with infestation level of *Chilopartellus*.

Stem thickness

The Stem Thickness in different genotypes was ranged from 24.25 mm to 32.00 mm in which the maximum stem thickness was observed in RHM-2; P3550 (32.00 mm) followed by Shaktiman-5 with 31.25 mm and Dekalb 9188 with 31.50 mm of stem thickness and also, they were found superior than resistant check. Minimum average stem thickness was recorded in RHM-3; Deep Jwala; New Cross (52×65); New Cross (73×74); New Cross (73×11) with 24.50 mm followed by New Cross (72×70) with 24.75 mm of stem thickness. The stem thickness in resistant check Lakshmi was 25.50.

Number of nodes per genotype

The number of nodes in different genotypes was ranged in between 14.00 to 18.50 nodes. Superior number of nodes was observed in RHM-3, P-3555 and New Cross (72×70). Minimum nodes were recorded in Shaktiman-3 with 14.00 followed by P-3535; New Cross (53×52); P-3533; Devaki with 15.25 and Shaktiman-1; RHM-2 with 15.50 nodes. Number of nodes found in resistant check was 16.50 that were at par with Shaktiman-1 & 5, New Cross (73×11), New Cross (73×74), New Cross (53×65). Similarly, Bhoi *et al*. (2019) [7]; Sahoo *et al.* (2021) [10, 18]; Afzal *et al*. (2009) [1] and Munyiri *et al*. (2012) [16] have reported significant increase in number of nodes as age increased; they have recorded range of number of nodes at 40 days of sowing (5.50 to 6.50) and at tasselling stage (13.00 to 15.00).

Internode length

The inter-node lengths in different genotypes were ranged from 12.29 cm to 17.17 cm in which the maximum internode length was recorded in RHM-3 with 17.17 cm followed by Deep Jwala with 17.15 cm and New Cross (50X58) with 17.07 cm of internode length and these were found superior. Minimum internode length was observed in RHM-2 with 12.29 cm followed by P-3550 with 12.93 and Shaktiman-5 with 13.05 cm. In resistant check Lakshmi, the Internode length was 15.47 and other a few genotypes were found at par with resistance check.

Trichome density

Trichome density in different genotypes were ranged from 98.25/cm^2 to 116.50/ cm^2 in which the maximum leaf trichome density per cm^2 were recorded in New Cross (72X70) with 116.50 trichomes/cm^2 followed by Suwan with 116.00 and Deep Jwala with 115.50 trichomes/cm^2 and they found superior to the check. The minimum trichome density per cm^2 were recorded in Shaktiman-1 with 98.25 leaf trichome numbers per cm^2 followed by New Cross (73X11) with 99.25 and P-3550 with 99.75 leaf trichome density per cm^2. Leaf trichome numbers in Lakshmi (resistant check) were 106.00/ cm^2 and that were at par with the Shaktiman-2 & 4, P-3533, P-3555, New Cross (76X11) and New Cross (73X11). The distribution of trichomes on leaves done by Munyiri *et al*. (2013) and they concluded that increasing the

Table 1: Various Morphological parameters and Per cent infestation Caused by Maize Spotted Stem Borer, *Chilopartellus* in various maize Genotypes

S. No.	Name of Genotypes	Morphological Parameters							Infestation Per Cent
		Plant Height	Stem Thickness	Number of Nodes	Internode Length	Trichome Density	Trichome Length	Leaf Angle	
1.	Shaktiman-1	117.38	29.5	15.50	14.32	98.25	11.88	47.50	24.87
2.	Shaktiman-2	123.63	28.00	15.75	14.46	106.25	11.73	49.75	26.00
3.	Shaktiman-3	121.50	27.25	14.00	15.13	103.00	10.20	53.75	29.00
4.	Shaktiman-4	121.00	27.50	16.25	15.35	108.25	11.41	60.25	24.25
5.	Shaktiman-5	106.50	31.50	17.00	13.05	104.75	8.20	50.50	48.50
6.	Devaki	112.38	25.75	15.25	16.66	102.00	7.63	51.25	33.20
7.	Lakshmi (Resistant, Check)	128.13	25.50	16.75	15.47	106.00	8.27	54.50	18.25
8.	Suwan	120.25	28.00	16.25	16.39	116.00	8.50	53.50	25.50
9.	RHM-1	122.13	27.50	16.25	14.97	103.75	10.07	62.25	25.37
10.	RHM-2	103.25	32.00	15.50	12.29	101.25	12.36	46.00	52.75
11.	RHM-3	152.50	24.50	18.50	17.17	113.75	7.34	61.50	16.75
12.	Deep Jwala	148.75	24.50	18.25	17.15	115.50	6.40	60.00	17.87
13.	P-3535	160.50	27.50	15.25	16.61	104.00	7.98	61.50	27.37
14.	P-3533	123.75	26.50	15.25	15.25	106.25	8.60	58.00	22.62
15.	P-3550	107.00	32.00	15.75	12.93	99.75	9.08	60.50	48.00
16.	P-3555	112.25	26.50	18.50	14.94	106.75	9.13	51.25	37.50
17.	DeKalb 9188	117.25	31.25	16.00	13.97	105.00	9.66	53.25	41.87
18.	DeKalb 9170	117.25	26.00	16.25	14.76	114.25	10.29	60.00	27.70
19.	New Cross (76×11)	136.50	27.25	15.75	14.67	106.50	12.16	53.25	25.25
20.	New Cross (72×70)	154.50	24.75	18.50	16.87	116.50	6.34	63.50	16.12
21.	New Cross (73×11)	135.00	24.50	17.50	16.12	99.25	6.82	57.00	21.00
22.	New Cross (73×74)	135.00	24.50	17.00	16.68	106.25	7.125	58.25	18.86
23.	New Cross (52×65)	141.50	24.50	17.50	17.01	112.50	7.34	59.75	17.87

24.	New Cross (53×52)	131.75	27.75	15.25	16.30	114.50	9.17	49.00	27.00
25.	New Cross (50×58)	131.50	28.75	17.50	17.07	108.50	8.72	50.75	21.62
CD ≤ 5%		3.12	1.06	1.17	1.10	3.40	0.91	2.50	2.31
SEm (±)		1.12	0.39	0.40	0.41	1.09	0.32	0.84	0.78

Trichome numbers results in decreasing the infestation levels and established a negative correlation between trichome number and infestation. It was observed that the correlation between trichome number and infestation was negative significant (-0.451) which was in line with the stated findings.

Leaf trichome

The leaf trichome lengths in different genotypes were ranged from 6.34 to 12.36 µmin which the maximum leaf trichomes was recorded in RHM-2 with 12.36 µm followed by New Cross (76X11) with 12.16 and Shaktiman-1 with 11.88 µm trichome lengths and they were superior to check. Minimum trichome length was observed in New Cross (72X70) with 6.34 µm followed by Deep Jwala with 6.40 and New Cross (73X11) with 6.82 µm trichome lengths. Trichome length in resistant check Lakshmi was 8.27 µm and Shaktiman-5, Devaki, New Cross (53X52) and New Cross (50X58) were found at par with the resistance genotypes.

Per cent infestation

The total per cent infestation in different genotypes was ranged from 16.12 to 52.75 per cent in which the maximum per cent infestation was observed in RHM-2 with 52.75 per cent followed by Shaktiman-5 with 48.50 and P-3550 with 48.00. Genotypes like Dekalb 9188, Shaktiman-3, P-3535 and others were found superior to check Lakshmi (18.75) in intensity of infestation. Minimum per cent infestation was recorded in New Cross (72X70) with 16.12 per cent followed by RHM-3 with 16.75 and Deep Jwala with 17.87 of per cent infestation. The per cent infestation in resistant genotype, Lakshmi was 18.75 per cent which were at par with New Cross (73X11) and New Cross (50X58).

Table 2: Correlation between Morphological traits of Maize Genotypes and Total

S.No.	Traits and Correlation values		Correlation
1.	Total Infestation Per Cent		
A.	Plant Height	-0.797	Negative, Significant
B.	Stem Thickness	0.251	Positive, Non-Significant
C.	Number of Nodes	-0.182	Negative, Non-Significant
D.	Inter-node Length	0.180	Positive, Non-Significant
H.	Trichome Number	-0.451	Negative, Significant
I.	Trichome Length	0.498	Positive, Significant
J.	Leaf Angle	-0.676	Negative, Significant

Infestation

Table 2 showed correlation between various morphological traits and infestation. Among all the tested attributes, the maximum correlation with infestation was recorded in Plant Height (-0.797) followed by Leaf Angle (-0.676), Trichome Length (0.498) and Trichome Density (-0.451). These attributes of maize were found significantly associated with infestation levels of *Chilopartellus* and considered to be the infestation governing factors in maize genotypes for the given test insect.

In the study of Afzal *et al*. 2009 [1]; Munyiri *et al*. (2012) [16]; Arabjafari and Jalali, (2007) [4]; Dash *et al.* (2021) [10] they have mentioned a clear-cut effect of morphological characters on infestation levels. In above mentioned researchers, Arabjafari and Jalali, (2007) [4] have conducted their studies on total 26 local landraces and they observed variation in the stem diameters (27.00 to 36.50 mm).

Conclusion

Recorded traits, *i.e.*, morphological traits like height of plant, stem thickness, number of nodes, inter-node length, trichome density and length of trichomes and leaf angle influenced by several interdependent environmental fluctuations leading to a difference in tracking of these traits. But these characteristics were found to be closely associated in related genotypes. In case of maize, non-glandular type of trichomes is found and distributed on both leaf surfaces and stem while on lower surface very less numbers of trichomes are found in a few genotypes. They can inhibit infestation in many ways including the inhibition of egg laying and movement of neonate towards the leaf whorl. There are significant negative association between trichome density and infestation, while in case of trichome length, a positive significant association has been found. Leaf angle was measured between the stem and leaf and it was observed that plants with minimum leaf angles, found to be having greater infestation. A negative and significant correlation has been observed between leaf angle and infestation of *Chilopartellus*. Among all the tested attributes, the maximum correlation with infestation was recorded in Plant Height (-0.797) followed by Leaf Angle (-0.676), Trichome Length (0.498) and Trichome Density (-0.451). These attributes of maize were found significantly associated with infestation levels of *Chilopartellus* and considered to be the infestation governing factors in maize genotypes for the given test insect.

References

1. Afzal M, Nazir Z, Bashir MH, Khan BS. Analysis of host plant resistance in some genotypes of maize against *Chilopartellus* (Swinhoe) (Crambidae: Lepidoptera). Pakistan Journal of Botany,2009:41:421-428.
2. Ali A, Khalil NR, Zia-ullah HD. Plant biochemical traits as resistance influencing factors in maize against *Chilopartellus* (Swinhoe). Journal of Entomology and Zoology Studies,2015:3(2):257-264.
3. Anonymous. Agricultural Statistics at a Glance, Govt. of India,2019:8(2):13-14.
4. Arabjafari KH, Jalali SK. Identification and analysis of host plant resistance in leading maize genotypes against spotted stem borer, *Chilopartellus* (Swinhoe) (Lepidoptera: Crambidae). Pakistan Journal of Biological Sciences,2007:10:1885-1895.
5. Arnon DL. Copper enzyme in isolated chloroplast and polyphenol oxidase. Plant Physiology,2010:24:71-80.
6. Benz, Bruce F. On the origin, evolution, and dispersal of maize. Pages 25–38 in Michael Blake, ed., Pacific Latin America in prehistory: the evolution of archaic and formative cultures. Washington State University Press, Pullman, 1999.

7. Bhoi TK, Trivedi N, Kumar H, Samal I, Tanwar AK, Hasan F *et al*. Components of host plant resistance to insect pests with specific emphasis on spotted stem borer, *Chilopartellus*in maize. Journal of Pharmacognosy and Phytochemistry,2019:8:942-948.
8. Chavan BP, Ankalkoppe MN, Teli VS, Khot RB, Harer PN. Incidence of insect pests on maize. Journal of Maharashtra Agricultural Universities,2006:31(3):388.
9. Dalin P, Agren J, Bjorkman C, Huttunen P, Karkkainen K. Leaf Trichome Formation and Plant Resistance to Herbivory. In A. Schaller (Ed.), Induced Plant Resistance to Herbivory. Springer Science & Business Media, 2008, 89-105.
10. Dash Lipsa, Sandeep Rout, Udit Nandan Mishra, Gyanaranjan Sahoo, Ajay Kumar, Prusty *et al*. Insecticidal genes in Pest Management. Annals of the Romanian Society for Cell Biology,2021:25(6):56015608.
11. Franklin S, Day AG, Brooks G. U.S. Patent No. 8,450,083. Washington, DC: U.S. Patent and Trademark Office, 2013.
12. Kakar AS, Kakar MK, Khan MT. Studies on vertical screening of maize against maize stem borer Chilopartellus. Journal of Biological Sciences,2003:3(2):233-236.
13. Kumar A, Arunita R, Naresh K, Mangilipelli Y, Vijayalakshmi T, Jainender M *et al*. Genetic diversity of maize genotypes on the basis of morpho-physiological and simple sequence repeats (SSR) markers. African Journal of Biotechnology,2012:11(99):6468-16477.
14. Kumar H, Saxena KN. Resistance in certain maize cultivars to first and third instar *Chilopartellus* larvae. Entomologia Experimentalis et Applicata,1992:65:75-80.
15. Mathur LML. Insect pest management and its future in Indian maize programme. Third International Congress of Entomology,1992:3(4):325-327.
16. Munyiri SW, Mugo SN, Otim M, Mwololo JK, Okori, P. Mechanisms and sources of resistance in tropical maize inbred lines to *Chilopartellus*stem borers. Journal of Agricultural Sciences,2012:5(7):51-60.
17. Rahman KA. Biology and control of maize and jowar borer (*C. partellus*). Indian Journal of Agricultural. Sciences,1994:14:303-307.
18. Sahoo G, Swamy SL, Rout S, Wani AM, Mishra A. Exploitation of Wild Leafy Vegetables and Under-utilized Fruits: Consequences for Food and Nutritional Security. Annals of the Romanian Society for Cell Biology,2021:25(6):5656-5668.
19. Uttam S, Fayiga A, Sonon L. Selenium in the soil-plant environment: A review. International Journal of Applied Agricultural Sciences,2017:3(1):1-18.
20. Weatherwax P. History and origin of corn. I. Early history of corn and theories as to its origin. Corn and corn improvement, 1955, 1-16.