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Original Research Article

Assessment of Different Insecticides against Maize Stem Borer Infestation

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A B S T R A C T

It is evident that all the treatments were significantly effective in reducing the maize stem borer infestation as compared to check (TO1) but, TO 4: Two spray of Monocrotophos 36SL @ 1 ml/lt. water was the most effective. The correlation coefficient revealed that number of leaves per plant (r = -0.9993), leaf length (r =-0.9600) and leaf width (r = -0.9884) had non-significant negative correlation with mean leaf injury level. Various plant characteristics correlated with tunnel length and found that the stem diameter (r = -0.9971) and plant height (r = -0.9599) had non-significant negative correlation with mean tunnel length. Whereas, cob height (r = -0.9140), cob length (r = -0.5880) and length of central spike (r = -0.8902) showed significant negative and significant correlation with mean tunnel length.

Keywords

Insecticides, Stem borer of maize

Introduction

Maize (*Zea mays* L.) or corn is a crop of the family Poaceae grown primarily for its kernel. It is the most versatile crop with wider adaptability in varied agro-ecologies and has highest genetic yield potential among the food grain crops. Maize (*Zea mays* L.) is the most completely domesticated crop among the cereals. Mexico or Central America is most likely being the origin of corn (Martin *et al.*, 2002). In India, maize is the most important cereal after wheat and rice. It is a multipurpose crop, providing food and fuel for human, feed for poultry and livestock and have a great nutritional value. It also serves as a source of raw material for producing hundreds of industrial products like starch, protein, oil, alcoholic beverages, food sweeteners, pharmaceuticals, cosmetics, biofuel, etc. At present, out of the total maize produced, 55 per cent is used for food purpose, about 14 per cent for livestock, 18 per cent for poultry feed, 12 per cent for starch and one per cent as seed. Maize is composed of 71.5 per cent starch, 1.9 per cent protein, 4.8 per cent fat and 1.4 per cent ash (Rathore, 2001). The ability of the maize crop to grow in different seasons and high productivity of rabi and spring maize give it an added advantages for inclusion in the cropping system to cope up with the demand for more food. Inclusion of maize in rice-wheat growing areas is a useful proposition. Therefore, it is emerging as a potential driving force for diversification i.e. diversification of rice-rice with rice-maize and, other maize based high value cropping systems, in water scarcity area. Lowering water table is a major concern in rice growing belt of India and making rice cultivation non-remunerative. Hence, maize has emerged as a potential as well as a profitable crop in these areas. In India the total area, production and productivity under maize crop during 2013-14 were 9.40 million ha, 23.00 million tonnes and 2.50 tonnes per ha respectively. (Anonymous, 2014). Peninsular India is considered to be a neutral environment for maize wherein maize can be cultivated in either of the seasons. The replacement of traditional local cultivars with the commercial varieties and hybrids led to expansion of arthropod pest complex. Pests of minor importance are now assuming major status. Maize crop is subjected to attack by over 130 insect pests during different stages of its growth. However, only about a dozen are quite serious (Siddiqui and Marwaha 1993). Among them some important lepidopteran stem borers seriously affects the attainable yields by infesting the crop throughout its growth, from seedling stage to maturity. Maize production is severely affected by maize stem borer to the degree of 15 -60%. A loss of 24-75% has been reported by the attack of this pest alone (Kumar, 2002). Maximum stalk damage in maize and up to 80% grain yield loss in sorghum by *Chilo partellus* were reported in 20 days old crops, whereas, similar infestations induced no significant loss when plants were infested soon (6 days) after emergence (Van den berg, 2009). 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 monocropping practiced by the farmers using indiscriminate use of insecticides and chemical fertilizers. Insects attack maize throughout the cropping cycle and during storage, resulting in as little as 10% to complete loss (Bergvinson *et al.*, 2002).

In India, maize production is greatly affected by the infestation of two insect pests, spotted stem borer, *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) and pink stem borer, *Sesamia inferens* Walker (Lepidoptera: Noctuidae). Spotted stem borer is restricted to the northern part of the country during rainy season while pink stem borer causes extensive damage to the crop in the peninsular India throughout the year and across the country. During the winter season pink borer with more extensive coverage, may cause damage up to 78.9% to the crop. It is a pertinent point to note that productivity of maize in peninsular India is higher than the northern states, and that of winter maize (3.22 t/ha) is higher than the rainy season maize (1.74 t/ha). Thus, to stabilize the maize production effective control of pink borer is of immense importance. (Santosh *et al.*, 2012). Indiscriminate use of chemical pesticides in the past has created a number of problems like insecticide resistance, insecticide residues, pest resurgence, environmental pollution and direct and indirect hazards to human beings etc.

To avoid or minimize these adverse effects, recently, emphasis has been given to explore new techniques for the management of insect pest with minimum use of pesticides at appropriate time or at vulnerable stage of insect biology. Keeping in view the importance of the crop as well as importance of the maize stem borer, this study was initiated to investigate the level of infestation of the maize stem borer in the stubbles and stalks at farmer's fields in the main maize growing area of Dumka district of Jharkhand, India.

Materials and Methods

Leaf injury rating (LIR)

Leaf injury rating of 1-9 scale (Kumar *et al.*, 2012) was used for screening the maize hybrid at 60 days after emergence of the crop. The maize hybrids were categorized into 3 groups. (1) Least susceptible, with mean leaf injury rating <3, (2) moderately susceptible with mean leaf injury rating >3 but <6 (3) highly susceptible, and with mean leaf injury rating >6.The rating recorded on five plants was averaged to get a mean score for each replication.

Dead heart percentage

Five maize hybrid plants were chosen randomly at 60 days after sowing and the per cent dead hearts caused by *Chilo partellus* were counted individually and after summing up it, the mean dead heart value was worked out. The percent plant with stem borer infestation was worked out using following formula:

$$\text{Percent plants with dead heart} = \frac{\text{No. of plants with dead hearts}}{\text{Total no. of plants}} \times 100$$

Stem holes and Tunnel length

Number of exit holes in maize plants was counted at 60 days after sowing and stem tunneling (cm) caused by *Chilo partellus* was measured at harvest in five randomly selected plants after uprooting and dissecting it and then their overall mean values were calculated. Based on the length of tunnels caused by the larvae of *Chilo partellus* were grouped under following 3 categories: (1) least susceptible, with mean tunnel length ranges between 0-5 cm (2) moderately susceptible, with mean tunnel length ranges between 5-10 cm (3) highly susceptible, with mean tunnel length more than 10 cm. (Lella and Srivastav, 2013).

Grain yield

Grain yield of 10 plants was recorded and then were computed and subjected to analysis of variance under RBD and the data were analyzed statistically.

Further, hybrids from each category showing least susceptible, moderate susceptible and highly susceptible based on leaf injury rating and tunnel length were studied in detail for morphological characters for resistance against *Chilo partellus.*

Biophysical/morphological traits

The morphological leaf characters were recorded at 60 days old crop for five randomly selected plants per treatment. These include number of leaves per plant, leaf width (cm) and leaf length (cm). At harvest other plant characteristics such as plant height (cm), cob height (cm), stem diameter (cm), cob length (cm), length of central spike (cm) and 100 grain weight (g) were recorded. The procedure adopted for these studies is described as under:

Leaf Characteristics

Number of leaves per plant

Number of leaves per plant was calculated from five randomly selected plants from each treatment.

Leaf length (cm)

The length of leaf blade was recorded with the measuring tape from five randomly selected plants and the average was computed.

Leaf width (cm)

The leaf width was measured from the centre of leaf blade from five randomly selected plants with the help of measuring tape and the average was calculated.

Plant Characteristics

Plant height (cm)

Five plants from each treatment were selected randomly at reproductive stage of the crop, and the height was measured with the help of measuring tape. Finally average was calculated.

Stem diameter (cm)

Stem diameter from five randomly selected plants from each treatment was recorded from 3 rd internodes above ground level with the help of a vernier caliper. The observations were then averaged to get mean values.

Cob length (cm)

Length of each cob was measured from five randomly selected plants with a measuring tape and average was calculated to get the mean cob length from each treatment.

Cob height (cm)

Cob height above the soil level from five randomly selected plants was measured with the help of measuring tape up to the node position of cob and then average was calculated.

Length of central spike

Length of central spike from five randomly selected maize plants was measured then average to get mean length.

100 Grains weight (g)

Five plants per genotype were randomly selected at maturity and cob removed and sun dried for one week. The grains were separated and mixed and 100 grains were taken at random and weighed with an electronic balance to calculate the average weight in grams.

Correlation and regression studies

The role of morphological plant characters with leaf injury rating and tunnel length in centimeters were worked out by processing the data into correlation coefficient values.

Evaluation of insecticides under field conditions

An experiment was carried out in the field also to evaluate the efficacy of three chemicals against stem borer on maize crop. The experiment was carried out by sowing K-25 hybrid in randomized block design (RBD) with ten replications. Row to row and plant to plant spacing were 75 cm and 25 cm, respectively. Insecticides from different chemical groups which were mostly used against the stem borers as foliar sprays (liquid formulations) and whorl application (granular formulations).The treatment was given at 15and 30 days after germination of the crop when stem borer infestation was observed in the field. All the data recorded in the study were subjected to statistical analysis. Statistical significance was tested with the help of “T- test”.

Results and Discussion

Nature of Damage

Leaf injury rating (LIR)

Data recorded on maize borer, *Chilo partellus,* percent infested plants and yield in different control methods applied alone and in combination are presented in Table 1. Statistical analysis of data showed that all treatments were significantly different as compared to control. Lowest leaf injury of maize stem borers (7.23%) was found in plots treated with TO 1 (Farmers Practice) followed by TO2 (6.50%). The lowest maize stem borer percent infested plants were observed in TO4 (2.42%) which were significantly lower than the all other treatments.

Per cent Dead Hearts

Results revealed that there was significant difference among the treatments in production of dead hearts expressed as percentage. Maximum of 8.33 per cent dead heart was recorded in TO1 followed by TO2 (Furadon). The minimum per cent dead heart was recorded in TO4 (2.21).

Stem Holes

Infestation of maize crop with *Chilo partellus* not only resulted in leaf injury, dead heart formation but also stem damage that was observed with the evident of the symptoms like exit holes on the stem. The data showed that minimum stem holes (1.73holes//plant) was onTO4 (Two spray of Monocrotophos 36SL @ 1 ml/lt. water). The stem holes were significantly more in TO1 (1.73 holes/plant) and moderately susceptible on TO2 and TO3 with stem holes of 0.61 and 0.40 holes/plant respectively. Present findings are in confirmation with those of Mulaa *et al.,* (2001) and Habib (2005) who reported that the higher number of stem borer exit holes indicated the higher borer survivorship and higher infestation level, and the fewer borer exit holes indicated the lower borer survival rate and infestation level

Tunnel Length

The data showed that minimum tunnel length (5.20 cm) was on TO4 (Two spray of Monocrotophos 36SL @ 1 ml/lt. water). The tunnel lengths were significantly more in TO1 (10.21 cm) and moderately susceptible on TO2 and TO3 with tunnel length of 9.31 and 6.76 cm respectively. The present findings are in close agreement with those of Cartea *et al.,* (1999) and Habib (2005) who reported that stem tunneling, among stalk damage traits, was a good indicator for stalk resistance Hardin (1984) also reported that second generation larvae of *Ostrinia nubilalis*, tunneled on an average 6 inches into stalks of resistant cultivars as compared with 12-20 inches in susceptible one.

Grain Yield

The yield obtained from different treatments showed that highest yield (37.60 q/ha) was obtained from TO4 followed by YO3 (34.10 q/ha). All the treated plots gave better grain yield as compared to control from where lowest yield (22.30 q/ha) was obtained from TO1. De-Groote (2002) in Kenya found grain yield losses of 12.9 per cent due to maize stem borer and Habib (2005) in Pakistan observed that losses in grain yield were lower in resistant genotypes (9.45 to 11.71 per cent).

Bio-Physical/Morphological Plant Characteristics

Various physical/morphological leaf and plant characters *viz.,* number of leaf/plant, plant height (cm) and leaf width (cm) were determined on 60 days old selected hybrids of maize. These factors were correlated with the leaf injury rating (LIR) (Table 2.1). The results are described under the following sub-sections.

Number of leaves per plant

The TO4 possessed the maximum number of leaves i.e. 9.15 followed by TO3 which recorded 8.10 leaves/plant.

Table.1 Damage caused by stem borer and its effect on yield

Treatment	Mean leaf injury	Dead hearts (%)	Stem hole (No.)	Tunnel length (cm)	Grain yield (q/ha)	B:C ratio
TO 1: FP	7.23	8.53 (16.73)	1.73 (7.50)	10.21 (12.65)	23.30	1:1.18
TO 2:Carbofuran 3G @10 granules/plant	6.50	8.82 (16.95)	0.61 (4.46)	9.21 (17.36)	25.80	1:1.29
TO 3:Two spray of Quibolphos 25 EC @ 1.5 ml/lt. water	4.40	6.55 (14.61)	0.40 (3.60)	6.76 (14.89)	34.10	1:1.43
TO 4:Two spray of Monocrotophos 36SL @ 1 ml/lt. water	2.40	2.21 (8.47)	0.31 (3.15)	5.00 (13.06)	37.60	1:1.58
SEm	0.38	0.26	0.058	0.26	1.09	-
CD at 5%	1.17	0.80	0.17	0.80	3.26	-

Figures in the parenthesis are angular transformed values.

Table.2 Leaf injury and various morphological leaf characteristics in 60 days old maize plant

Treatment	Mean leaf injury	No. of leaves /plant	Leaf length (cm)	Leaf width (cm)
TO 1: FP	7.23	6.81	49.12	6.16
TO 2:Carbofuran 3G @10 granules/plant	6.50	7.11	54.37	7.10
TO 3:Two spray of Quibolphos 25 EC @ 1.5 ml/lt. water	4.40	8.10	56.32	8.80
TO 4:Two spray of Monocrotophos 36SL @ 1 ml/lt. water	2.40	9.15	63.27	9.86
Correlation coefficient (r)		-0.9993NS	-0.9993NS	-0.9993NS

*****Significant at 5% level, NS- Non Significant.

Table.3 Correlation coefficient values between mean leaf injury and Physico-morphological characters of leaf

Leaf characters	Correlation coefficient values (r)
Number of leaves/plant	-0.9993NS
Leaf Length (cm)	-0.9600NS
Leaf width (cm)	-0.9884NS

*****Significant at 5% level, NS- Non Significant.

Table.4 Regression coefficient values between mean leaf injury and Physico-morphological characters of leaf

Leaf characters	Regression coefficient values (r)
Number of leaves/plant	-0.4855 NS
Leaf Length (cm)	-2.5755 NS
Leaf width (cm)	-1.2994NS

*Significant at 5% level, NS- Non Significant.

Table.5 Stem tunneling and various bio-physical/morphological plant characteristics

Treatment	Tunnel length (cm)	Stem diameter (cm)	Plant height (cm)	Cob height (cm)	Cob length (cm)	Length of central spike(cm)	100 grain weight (gm.)
TO 1: FP	9.37	1.45	179.10	86.76	17.88	21.53	16.56
TO 2:Carbofuran 3G @10 granules/plant	7.78	1.76	181.6	87.26	18.73	22.43	19.90
TO 3:Two spray of Quibolphos 25 EC @ 1.5 ml/lt. water	5.23	2.08	192.86	90.21	19.16	24.10	92.14
TO 4:Two spray of Monocrotophos 36SL @ 1 ml/lt. water	5.01	2.14	198.35	94.23	20.85	26.73	23.81
Correlation coefficient (r)		-0.9971 NS	-0.9599 NS	-0.9140*	- 0.5880*	-0.8902*	-0.5784*

*Significant at 5% level, NS- Non Significant.

Table.6 Correlation coefficient values Stem tunneling and various bio-physical/morphological plant characteristics

Stem characters	Correlation coefficient values (r)
Stem diameter(cm)	-0.9971 NS
Plant height (cm)	-0.9599NS
Cob height (cm)	-0.9140 *
Cob length (cm)	-0.5880*
Length of central spike(cm)	-0.8902*
100 grain weight (gm.)	-0.5784*

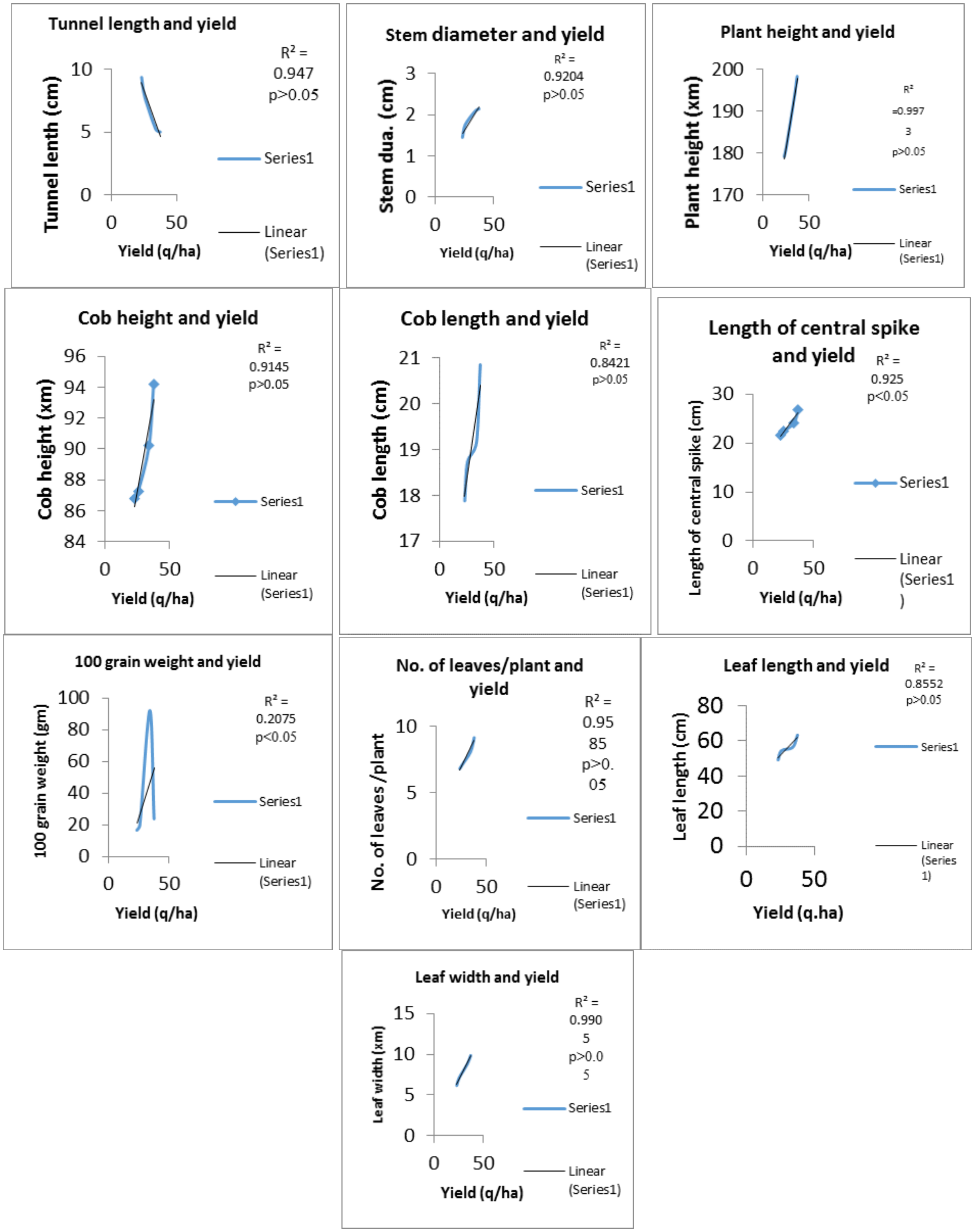
*Significant at 5% level, NS- Non Significant.

Table.7 Regression coefficient values Stem tunneling and various bio-physical/morphological plant characteristics

Stem characters	Regression coefficient values (r)
Stem diameter(cm)	-6.8203 NS
Plant height (cm)	-0.2204NS
Cob height (cm)	-0.5653*
Cob length (cm)	-0.0339*
Length of central spike(cm)	-0.8495*
100 grain weight (gm.)	-0.0349*

*Significant at 5% level, NS- Non Significant.

Fig.1 Relationship of stem borer damage parameters (tunnel length measurement, stem diameter, plant height, cob height, cob length, length of central spike and 100 grain weight) with grain yield; and relationship of no. of leaf/plant, leaf width with grain yield



The minimum number of leaves was recorded on the TO1 (6.81 leaves/plant) (Table 2).

Leaf length (cm)

Maximum leaf length of 63.27 cm was recorded in TO4 followed by TO3 (56.32 cm). Minimum leaf length was recorded TO1 (49.12 cm) followed by TO2 (54.37 cm).

Leaf width (cm)

Maximum leaf width of 9.86 cm recorded in TO4 followed TO3 (8.80 cm). The TO1 was recorded the with minimum leaf width (6.16 cm).

Correlation of leaf injury with bio – physical/Morphological characters of leaf

The correlation coefficient values between mean leaf injury level and bio –physical/ morphological leaf characters are given in Table 2.1.The results revealed that number of leaves per plant (r = -0.9993), leaf length (r =-0.9600) and leaf width (r = -0.9884) had non-significant negative correlation with mean leaf injury level (Table 4.7). These results are confirmed with earlier studies as Rao and Panwar (2000) screened seven maize genotypes against *C.partellus* and found that narrow leaf widths and high trichome densities were the main factors contributing to resistance.

Plant morphological characters of maize

Stem Diameter (cm)

The TO4 showed maximum stem diameter of 2.14 cm followed by TO3 (2.02 cm). The minimum stem diameter 1.45 cm was recorded in TO1 followed by TO2 (1.76 cm).

Plant Height (cm)

The maximum plant height was recorded to be 198.35 cm in TO4 followed TO3 (192.86cm). The shortest plants were observed in TO1 (179.10 cm) followed by TO2 (181.60cm) as against TO1.

Cob Height (cm)

The maximum mean cob height was recorded in TO4 (94.23 cm) followed by TO3 (91.21 cm).The minimum cob height was recorded to be 86.30 cm in TO1 followed by TO2 (87.26 cm).

Cob Length (cm)

The maximum mean length of cob was recorded in TO4 i.e.20.85 cm followed by TO3 (19.06 cm). The minimum cob length of 17.88 cm in TO1 followed by TO2 (18.73 cm).

Length of central spike (cm)

The data regarding length of central spike (cm) in various selected treatments of maize crop are presented in Table 3 shows that the maximum length of central spike was 26.73 cm on TO4 followed by TO3(24.10 cm).The minimum length of central spike was observed to be 21.53 cm in TO1 followed by TO2(23.43 cm).

100- Grain Weight (gm)

Variations were found among treatments regarding 100-grain weight in selected options.

The maximum 100-grain weight was recorded in TO4 with 23.81 g which was followed by TO3 (22.10 gm). The minimum grain weight was recorded in TO1 with grain weight of 16.56 gm

Correlation of tunnel length with bio–physical/morphological characters of plant

The correlation coefficient values between tunnel length (cm) are given in Table 3.1.The results revealed that stem diameter (r = -0.9971) and plant height (r = -0.9599) showed non-significant negative correlation with mean tunnel length. Whereas, cob height (r = -0.9140), cob length (r = -0.5880) and length of central spike (r = -0.8902) showed significant negative and significant correlation with mean tunnel length. Out of these different morphological traits of the host plants length of central spike, cob height and length of cob were more and strongly correlated with the length of damaged tunnel caused by the stem borer. However, 100 –grain weight also showed significant negative correlation (r = -0.5784) with mean tunnel length. Muhammad *et al.,* (2009) found that the correlation coefficient values between infestation of plants and morphological plant characteristics that stem diameter, cob length, leaf length, leaf width, leaf trichomes and 100 grain weight exerted significant and negative correlation with plant infestation showing r values of - 0.572, - 0.545, - 0.542, - 0.620, - 0.880 and - 0.559, respectively.

However, Ali *et al.,* (2015) correlated number of nodes per plant; cob length, trichomes density and 100- grain weight with plant infestation per cent and found significant but negative correlation, whereas stem diameter had positive and significant correlation. Furthermore, plant height, cob height and length of central spike had non-significant correlation with the plant infestation. Stem structural traits related to the entry point and tissues on which larvae feed and to determine the relationship between these stem structural traits and the stem borer résistance.

Relationship of stem borer damage parameters

All the observed damage parameters of maize stem borers had not exert a significant impact on grain yield however; length of central spike and 100-grain weight had a significant positive role for grain production (figure1).

It is evident that all the treatments were significantly effective in reducing the maize stem borer infestation as compared to check (TO1). TO 4:Two spray of Monocrotophos 36SL @ 1 ml/lt. water was the most effective control method for controlling maize stem borer and obtaining higher yield of maize grain. The correlation coefficient values between mean leaf injury level and bio –physical/ morphological leaf characters revealed that number of leaves per plant (r = -0.9993),leaf length (r =-0.9600) and leaf width (r = -0.9884) had non-significant negative correlation with mean leaf injury level. Various plant characteristics *viz.* stem diameter, plant height (cm), cob height (cm), cob length (cm), length of central spike (cm) and 100-grain weight were correlated with tunnel length and found that the stem diameter (r = -0.9971) and plant height (r = -0.9599)had non-significant negative correlation with mean tunnel length. Whereas, cob height (r = -0.9140), cob length (r = -0.5880) and length of central spike (r = -0.8902) showed significant negative and significant correlation with mean tunnel length.

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