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Antixenosis and antibiosis of sugarcane varieties on the incidence of sugarcane internode borer, *Chilosacchariphagus indicus*

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Abstract
In vivo experiment was conducted to screen 20 genotypes against internode borer, *Chilosacchariphagus indicus* (Kapur) (Crambidae: Lepidoptera) at the Zonal Agricultural Research Station, College of Agriculture, V. C. Farm, Mandya, during the period 2016-17. The study revealed a significant positive correlation with cane length, length and girth of vulnerable portion. Biochemical analysis of the genotypes indicated lower quantity of total sugars and reducing sugar and higher quantity of phenols, cellulose, tannin were found imparting resistance to INB of sugarcane.

Keywords: Antixenosis, antibiosis, *Chilosacchariphagus indicus*, internode borer

Introduction

Based on feeding habit, the insect pests of sugarcane are broadly classified as borers, sucking pests, subterranean pests, defoliators and non-insect pests. The nine species of lepidopteran pests regularly damage sugarcane [3] in India. Among the major species of borers, *Chilosacchariphagus indicus* (Kapur) (Crambidae: Lepidoptera), commonly known as internode borer, has remained a major pest in peninsular India [5]. Internode borer generally attacks the crop from internode formation to harvest, causing estimated crop losses of 10–35% [12]. When the borer injury extends to three or more internodes per cane, or more than 10% of the total length of the cane, canes suffer significant deterioration in juice quality. The threshold for the internode borer was found to be 13 - 15 per cent bored internodes.

Several control methods have been evaluated from time to time. Among the different management strategies, the use of tolerant genotype is one of the important components of IPM. So, different genotypes have been screened under natural conditions to identify the less susceptible genotypes to internode borer. Among the screened genotypes the morphological and biochemical parameters that impart resistance to internode borer were investigated. Knowledgeon resistance which is useful in future breeding programme.

Material and Methods

Antixenosis and antibiosis components of resistance to the INB, *C. saccharipgagus indicus* was studied in twenty selected sugarcane genotypes under natural field conditions at the Zonal agricultural research station, V.C. farm, Mandya. Based on the per cent incidence of INB, the sugarcane genotypes were graded according to [9] as given below.

Category

Grade/ Category	% Incidence
Less susceptible (LS)	Below 20
Moderately susceptible (MS)	20.1-40
Highly susceptible (HS)	Above 40

$$\text{Incidence (\%)} = \frac{\text{Total number of affected canes}}{\text{Total canes}} \times 100$$

The 20 genotypes were selected to identify the biophysical and biochemical differences between the selected promising genotypes. In each grade of infestation, six genotypes will be selected for morphological studies to know the basis of resistance in sugarcane to INB. The Influence of susceptibility or tolerance of genotypes will be investigated systematically along with varieties Co 86032 and Co 62175 For this, five randomly selected plants were used and observations on physical parameters like leaf width, length of internodes, cane length, length and girth of vulnerable portion, nature of leaf sheath and nature of leaves were recorded. The biochemical factors associated with resistance and susceptibility among the twenty selected genotypes, the cane samples were collected from field at the time of harvest. The estimation of biochemical constituents *viz*., total sugars and reducing sugars (Nelson and Somogyi method) [10] total phenols (Folin-Ciocalteau method) [3], cellulose [13], tannins contents (Folin-Denis method) [4] in cane samples were estimated. The data obtained was subjected to ANOVA [4, 6] and was correlated with the per cent incidence of internode borer to calculate the ‘r’ value.

Preparation of samples

Shade dried sugarcane powder weighing 25-30g of each genotype was collected and brought to laboratory, for the estimation of total soluble sugars, reducing sugars, phenols, proteins, cellulose, tannin and nitrogen content.

Results and Discussion

Twenty genotypes were selected showing less susceptible, moderately susceptible and highly susceptible to INB for further studies along with the checks Co 86032 and VCF 0517. The results of field screening of different genotypes for resistance to INB revealed that the less susceptible genotypes had less than 20 per cent of INB incidence *viz.,* 15-22-75 (10.00%), 15-22-42 (13.33%), 10-14-16 (16.67%), and moderately susceptible genotypes had per cent incidence in the range of 20-40 per cent *viz.,*10-57-07 (20.00%), 15-33-36 (23.33%), 07-06-05 (30.00%), 15-22-50 (33.33%), 09-30-01 (36.67%), 10-43-06 (40.00%), highly susceptible genotypes has more than 40 per cent of INB incidence *viz.,* 15-22-47 (43.33%), 09-61-07 (46.92%), 09-65-04 (76.67%) and the checks Co 86032 and VCF 0517 had per cent INB incidence of 16.67 and 40.00%, respectively at 12 months after planting. The cane samples of these twenty genotypes were collected at harvest and utilized for further studies (Table 1).

Morphological parameters

In the present investigation, the results of various morphological characters like leaf width, length of internodes, length of cane, girth and length of vulnerable portion, nature of leaf sheath and leaves on the incidence of sugarcane internode borer were observed and has been presented in Table 1. A simple correlation between the incidence of INB and the plant characters was worked out and presented in the Table 2.

Width of leaf

The maximum width of leaf was recorded in genotypes, 10-43-06 (3.37 cm) and 15-22-75 (3.22 cm) with the INB incidence 40.00 per cent and 23.00 per cent, respectively and minimum leaf width was found in the genotypes, 15-33-53 (1.63 cm) and 15-22-76 (1.94 cm) with the INB incidence of 43.33 per cent and 30.00 per cent, respectively (Table 1). However, a non-significant correlation (r=0.18) was observed between the width of leaves and incidence in different genotypes (Table 2). The present findings are in agreement with reports of [1].

Length of internodes

The length of internodes varied from14.07 cm to 16.29 cm in different genotypes. The length of internodes was maximum (16.29) in MS genotype, 07-06-05 with INB incidence of 30.00 per cent. Shortest internode length (14.07 cm) was found in LS genotypes 15-22-42 with the incidence of 13.33 per cent (Table 1). A non-significant correlation was found (r= 0.19) between length of internodes and INB incidence (Table 2). Present findings are in agreement with findings of [1].

Length of cane

Thecane length ranged from 1.27 m to 1.73 m in less susceptible, 1.53 m to 1.87 m in moderately susceptible and 2.17 m to 2.97 m in highly susceptible genotypes, respectively. The LS genotype, 15-22-42 having significantly lower cane length (1.27 m) with 10.00 per cent incidence, and the HS genotype, 15-22-47 having significantly higher cane length (2.97 m) with the INB incidence of 76.67 per cent. Whereas, checks Co 86032 and VCF 0517 registered 1.93 and 2.57m of cane length with the incidence of 16.67 and 40.00 per cent, respectively. A significant positive correlation was observed between the length of cane (r= 0.43) and per cent incidence of INB in different genotypes. The results obtained with cane length are in conformity with the findings of [1] who reported that a positive significant correlation between the height of canes and incidence of INB. It may be because tall canes were preferred by the moths for oviposition.

Length of Vulnerable portion

The less vulnerable portion length was recorded in LS genotypes and it ranged from 15.17 cm to 16.47 cm with an INB incidence of 10.00 to 16.67 per cent. Whereas more vulnerable length was recorded in HS genotypes and it ranged from 18.67 cm to 19.03 cm with an INB incidence ranging from 43.33 to 76.67 per cent (Table 1). Whereas, check Co 86032 and VCF 0517 registered 17.47 cm and 19.00 cm of vulnerable length with INB incidence of 16.67 and 40.00 per cent, respectively. A significant positive correlation was observed between the length of vulnerable portion (r= 0.73) and INB infestation in different genotypes.

Girth of vulnerable portion

The girth of vulnerable portion varied from 2.53 cm to 1.36 cm in different genotypes. The maximum girth was recorded in HS genotype, 15-33-53 (2.53 cm) with the incidence of 43.33 per cent and the minimum girth was recorded in the genotype, 15.33-24 (1.36 cm) with the incidence of 16.67 per cent (Table 1). Girth of vulnerable portion showed significant positive correlation (r= 0.78) with the INB incidence (Table 2).

Nature of leaf sheath

The leaf sheath quite firmly wrapped around the internode in least susceptible genotypes than the highly susceptible genotypes. Whereas, in check Co 86032 and VCF 0517 recorded tight and loosely clasping with the incidence of 16.67 to 40.00 per cent, respectively (Table 1). In the present study genotypes with loose clasping leaf sheath were observed to be more damaged by internode borer than those with the tight clasping leaf sheath. The results revealed that with the loosely fitting leaf sheaths, the larvae may be finding it easier to get into the inner surface of leaf sheath for shelter and feeding during the first 8-10 days of larval life [1].

Nature of leaves

A visual examination of test genotypes revealed that the least susceptible genotypes had erect leaves. Whereas in highly susceptible genotypes *viz.*, 09-65-04, 15-22-47 and 09-61-07 had drooping nature of leaves (Table 1). Thereby, indicating a relationship of droopiness with INB susceptibility. The results pointed out that *C. sacchariphagus indicus* generally preferred to inhabit genotypes with drooping nature of leaves. This may be due to more shelter provided by genotypes with drooping leaves. The results obtained are in conformity with the findings of [12] who reported that the varieties having erect leaves were least attractive to the moths and young larvae of *Diatriasaccharalis.* The varieties with drooping canopy had higher incidence of *C. infuscatellus* than those having erect leaves [15].

Biochemical constituents

The influence of different biochemical constituents*viz.*, total sugars, reducing sugars, phenol, cellulose, tannin and protein content were estimated in different sugarcane genotypes on the incidence of sugarcane internode borer was observed and has been presented in Table 3. A simple correlation between the INB incidence and the biochemical components of sugarcane genotypes was worked out and presented in the Table 4.

Total sugars

The amount of total sugars in cane samples showed significant differences among the genotypes and the differences ranged from 6.43 to 8.55 per cent in LS genotypes, 9.47 to 10.64 per cent in MS genotypes and 10.72 to 12.93 per cent in HS genotypes. Total sugar was highest (12.93%) in the HS genotypes, 15-22-47 with the incidence of 43.33 per cent and was lowest (6.43%) in LS genotype, 15-22-75 with the incidence of 10.00 per cent. whereas check Co 86032 and VCF 0517 registered 7.53 and 11.36 per cent of total sugars with the INB incidence 16.67 and 40.00 per cent, respectively. An increasing trend of total sugar contents of cane samples of different genotypes was observed with increase in susceptibility of genotypes to INB. The correlation study between these two factors revealed significant positive relationship (r= 0.49) (Table 4).

The results from the above might be due to the role of sugars as a vital nutrient in plants and further the difference in the relative amounts of sugars between different genotypes with susceptibility to INB indicated that these might acts as a phagostimulant to sugarcane borer. These findings are in conformity with [2, 16] who reported a significant positive association with sugarcane borers and total sugars.

Reducing sugar

The LS genotypes contained significantly lower amount of reducing sugars and it ranged from 0.37 to 0.59 per cent and in HS genotypes contained significantly higher amount of reducing sugars (0.83 to 1.37%). The high amount of 1.37 per cent of reducing sugars was present in highly susceptible genotype, 09-65-04 with the INB incidence of 76.67 per cent. Lowest reducing sugars (0.37%) were found in the cane samples of LS genotypes, 15-33-35 with the incidence of 16.67 per cent. Whereas check Co 86032 and VCF 0517 registered 0.76 and 0.49 per cent of reducing sugars with the incidence of 16.67 per cent and 40.00 per cent respectively (Table 3). An increasing trend of reducing sugar contents of different genotypes was observed with increase in susceptibility to INB incidence. Further the correlation study reveals that there was a significant positive association between the reducing sugars and per cent INB incidence (r= 0.84).

Reducing sugars are essential component in insect nutrition, and their concentration in host plant positively correlated with feeding of insects; play a vital role in host selection by phytophgaus insects. The results are in agreement with earlier findings by [2 16]. They reported that sugarcane genotypes susceptible to shoot borer contained higher percentage of reducing sugars than resistant genotypes. Similar observations were also reported by [10] against *Heliothiszea*in corn.

Total phenol

The phenol content differed among the genotypes and it ranged from 7.58 to 9.56 mg/g in LS genotypes, 4.63 to 6.66 mg/g in MS genotypes and 4.59 to 6.36 mg/g in HS genotypes. The LS genotype, 15-33-24 contained significantly high phenol content (9.56%) with the INB incidence of 16.67 per cent and significantly lower phenol 4.59 per cent was found in the HS genotypes, 15-22-47 with the INB incidence of 4.59 per cent. Whereas, check Co 86032 and VCF 0517 recorded 7.84 and 5.46 per cent of phenol with the incidence of 16.67 and 40.00 per cent, respectively. The amount of total phenol content showed significant negative correlation with INB infestation (r= -0.62).

This indicates an increase in trend in phenol content in cane samples decreased the INB susceptibility. The results obtained are in agreement with the earlier reports by [2 16]. They have reported that sugarcane genotypes susceptibility to borer contained higher amount of phenol. Phenolic compounds have been implicated in the resistance of number of plants species to various pests like sugarcane borers and one of the important group of plant defense chemicals responsible for antifeedant or antibiotic effects on insects [15].

Cellulose

The amount of cellulose in cane samples showed differences among the genotypes. The cellulose content in LS genotype ranges from 16.87 to 23.32 per cent, in MS genotypes it ranged from 15.35 to 18.87 per cent and in highly susceptible genotypes it ranged from 7.60 to 11.10 per cent. Least susceptible genotype, 10-14-16 recorded significantly higher amount of cellulose (23.32%) with the INB incidence of 16.67 per cent. Low amount of cellulose (7.60%) in highly susceptible genotype, 15-22-47 expressed high INB incidence (76.67%). Whereas check Co 86032 and VCF 0517 registered 19.18 per cent and 15.46 per cent of cellulose with the INB incidence of 16.67 per cent and 40.00 per cent, respectively.

A decreasing trend of cellulose in cane samples increased the susceptibility and showed significantly negative correlation (r= -0.82) with INB susceptibility. The results obtained are in agreement with earlier reports by [14] who reported negative association between biochemical constituents like NDF, ADF, Phenol, Cellulose content in leaf sheath and stalk with susceptibility to stalk borer, *Chiloauricilius* in sugarcane.

Tannin

The tannin content in cane samples of LS genotype varied from 0.24 to 0.41 per cent, in MS genotype varied from 0.17 to 0.28 per cent and in HS genotype ranged from 0.16 to 0.20 per cent. The LS genotype, 10-14-16 contained significantly maximum amount of tannin (0.41%) with INB incidence of 16.67% and significantly minimum amount of tannin (0.16%) in the HS genotype, 15-22-47 with the INB incidence of 76.67 per cent. Whereas in check Co-86032 and VCF-0517 recorded 0.38% and 0.17% of tannin with the incidence of 16.67 per cent and 40.00 per cent respectively. The amount of tannin content showed significant differences among the genotypes indicating a negative correlation between tannin content and INB susceptibility (r=-0.65). [14] reported the similar results that higher content of tannin in different sugarcane genotypes cause significant deterrent effect on the sugarcane borer incidence and the higher concentration of tannin had been reported to show antibiotic effect in sorghum against shoot fly and stem borer [11].

Table 1: Correlation between morphological characters of different genotypes and per cent Incidence of sugarcane internode borer

Morphological parameters	Correlation with per cent incidence of INB
Leaf width (cm)	0.18
Length of internodes (cm)	0.19
Cane length (m)	0.43*
Length of vulnerable portion (cm)	0.73**
Girth of vulnerable portion (cm)	0.78**

**Correlation is significant at the 0.01 level *Correlation is significant at the 0.05 level

Table 2: Correlation between biochemical constituents of different genotypes and per cent incidence of sugarcane internode borer

Biochemical constituent	Correlation with per cent incidence of INB
Total sugars (%)	0.49*
Reducing sugars (%)	0.84**
Phenol (mg/g)	-0.62**
Cellulose (%)	-0.82**
Tannin (%)	-0.65**

**Correlation is significant at the 0.01 level *Correlation is significant at the 0.05 level

Table 3. Influence of morphological parameters of different sugarcane genotypes on percent incidence of *C. sacchariphagus indicus*

	Genotype	Incidence	Leaf width (cm)	length of internodes (cm)	length of cane (m)	length of vulnerable portion (cm)	Girth of vulnerable portion (cm)	Nature of leaf sheath	Nature of leaves
LS	10-14-16	16.67 (23.85)	2.14	15.44	1.73^{defg}	15.23^{ab}	1.37^{ab}	Tight	Erect
	15-33-35	16.67 (23.85)	2.50	15.18	1.30^{ab}	15.17^{a}	1.84^{ijk}	Tight	Erect
	15-33-24	16.67 (23.36)	2.14	16.11	1.30^{ab}	15.67^{cd}	1.36^{a}	Tight	Erect
	15-22-70	10.00 (18.43)	2.69	15.29	1.27^{a}	16.00^{de}	1.45^{abc}	Tight	Erect
	15-22-42	13.33 (21.14)	2.33	14.07	1.27^{a}	16.47^{f}	1.49^{abcd}	Tight	Erect
	15-22-75	10.00 (18.43)	3.27	15.07	1.47^{bc}	15.40^{abc}	1.52^{cde}	Tight	Erect
MS	07-06-05	30.00 (33.00)	2.13	16.29	1.67^{def}	17.23^{i}	1.56^{cdef}	Tight	Drooping
	09-30-01	36.67 (36.93)	2.00	16.03	1.67^{def}	16.73^{fg}	1.83^{hij}	Loose	Drooping
	10-43-06	40.00 (39.06)	3.37	15.11	1.70^{defg}	16.83^{fgh}	1.65^{efg}	Loose	Drooping
	10-57-07	20.00 (26.07)	2.03	16.07	1.87^{ghi}	17.43^{ijk}	1.69^{fgh}	Tight	Erect
	15-33-36	23.33 (28.28)	3.22	14.11	1.83^{fgh}	18.00^{lm}	1.72^{ghi}	Loose	Drooping
	15-22-50	33.33 (35.00)	2.49	14.88	1.57^{cde}	17.83^{kl}	1.84^{ijk}	Tight	Erect
	15-22-76	30.00 (32.21)	1.94	14.18	1.53^{cd}	18.43^{n}	1.84^{ijk}	Loose	Drooping
HS	09-61-07	53.33 (46.92)	2.08	15.11	2.17^{k}	18.67^{no}	2.23^{p}	tight	Drooping
	09-65-04	76.67 (62.70)	2.00	15.00	2.47^{m}	19.03^{opq}	1.85^{ijkl}	Loose	Drooping
	15-22-47	76.67 (61.21)	2.77	15.11	2.97^{o}	19.27^{pqrs}	2.17^{o}	Loose	Drooping
	15-33-61	43.33 (41.06)	2.09	15.07	2.17^{k}	19.73^{t}	1.90^{jklm}	Tight	Drooping
	15-33-53	43.33 (41.15)	1.63	15.07	2.20^{kl}	19.20^{pqr}	2.53^{q}	Loose	Drooping
Checks	Co -86032	16.67 (23.85)	2.15	15.18	1.93^{hij}	17.47^{ijk}	1.45^{abc}	Tight	Erect
	VCF 0517	40.00 (43.00)	2.2	14.55	2.57^{mn}	19.00^{op}	1.98^{klmn}	loose	Drooping
	SE m±	4.48	NS	NS	0.06	0.14	0.05	-	-
	CD@P=0.05	12.83			0.19	0.40	0.15	-	-

Table 4: Influence of biochemical constituents of different sugarcane genotypes on the percent incidence of *Chilosacchariphagus indicus*

	Genotypes	Incidence (%)	Total sugars (%)	Reducing sugars (%)	Phenol (mg/g)	Cellulose (%)	Tannins (%)
LS	10-14-16	16.67 (23.85)	6.54^{ab}	0.56^{bcde}	7.58^{b}	23.32^{a}	0.41^{a}
	15-33-35	16.67 (23.85)	7.56^{cde}	0.37^{a}	7.92^{b}	20.44^{a}	0.32^{a}
	15-33-24	16.67 (23.36)	8.50^{f}	0.46^{ab}	9.56^{a}	16.87^{c}	0.32^{ab}
	15-22-70	10.00 (18.43)	7.30^{c}	0.59^{cdef}	8.86^{ab}	22.20^{ab}	0.24^{abc}
	15-22-42	13.33 (21.14)	8.55^{fg}	0.49^{bc}	8.13^{ab}	22.30^{ab}	0.36^{abcd}
	15-22-75	10.00(18.43)	6.43^{a}	0.55^{bcd}	9.54^{a}	18.76^{bc}	0.32^{bcd}
MS	07-06-05	30.00 (33.00)	9.47^{h}	0.64^{defg}	5.92^{e}	18.87^{bc}	0.28^{cd}
	09-30-01	36.67 (36.93)	10.30^{k}	0.79^{jkl}	5.84^{e}	15.83^{dc}	0.22^{cde}
	10-43-06	40.00(39.06)	10.51^{kl}	0.68^{ghij}	4.63^{i}	17.59^{c}	0.24^{b}
	10-57-07	20.00 (26.07)	10.54^{klm}	0.66^{defghi}	6.66^{cd}	15.35^{dc}	0.26^{bc}
	15-33-36	23.33 (28.28)	9.72^{hij}	0.87^{klmn}	5.73^{ef}	17.45^{c}	0.27^{e}
	15-22-50	33.33 (35.00)	10.64^{klmn}	0.65^{defgh}	4.96^{gh}	18.43^{bc}	0.17^{de}
	15-22-76	30.00 (32.21)	9.64^{hi}	0.83^{klm}	5.24^{ef}	15.34^{d}	0.20^{bcd}
	09-61-07	53.33 (46.92)	10.72l^{mno}	1.12^{pq}	5.98^{gh}	14.07^{d}	0.19^{de}
	09-65-04	76.67 (62.70)	11.23^{q}	1.37^{r}	6.36^{c}	12.57^{dc}	0.20^{bc}

HS	15-22-47	76.67 (61.21)	12.93^{t}	0.83^{klm}	4.59^{g}	$7.60b^{cd}$	0.16^{abc}
	15-33-61	43.33 (41.06)	10.75^{lmnop}	0.96^{no}	4.91^{gh}	11.10^{cd}	0.18^{cd}
	15-33-53	43.33 (41.15)	12.38^{s}	1.03^{op}	4.93^{g}	11.73^{e}	0.21^{bc}
Checks	Co 86032	16.67 (23.85)	7.53^{cd}	0.76^{hijk}	7.84^{bc}	19.18^{b}	0.38^{bc}
	VCF 0517	40.00 (43.00)	11.36^{qr}	0.49^{bc}	5.46^{cd}	15.46^{cd}	0.17^{cd}
	SE m±	4.48	0.14	0.04	0.16	1.39	0.04
	CD@p=0.05	12.83	0.39	0.12	0.46	3.97	0.11

NS: Non significant; Values in the column followed by common letters are non-significant at p = 0.05 as per Tuckey's HSD (Tukey, 1965). Figures in the parentheses are arc sine transformed values.

Conclusion

Morphological characters of different genotypes on INB incidence revealed that the sugarcane internode borer incidence was highly influenced by cane length, nature of leaf sheath, nature of leaves, length and girth of vulnerable portion. The correlation study revealed no relationship between leaf width and length of internodes. Among the morphological parameters cane length (r=0.43), length of vulnerable portion (r=0.73) and girth of vulnerable portion (r= 0.78) had positive correlation with INB incidence.

Biochemical constituents of different genotypes on INB incidence revealed that the INB incidence was positively correlated with total sugars, reducing sugars and total protein and negatively correlated with phenols, cellulose and tannin. The minimum of 6.43 per cent of total sugars was recorded in less susceptible genotype, 15-22-75. Whereas maximum of 12.93 per cent of total sugars was recorded in highly susceptible genotype, 15-22-47. Similarly, minimum of 0.37 per cent of reducing sugars was recorded in less susceptible genotype, 15-33-35. Whereas maximum of 1.37 per of reducing sugars was recorded in highly susceptible genotype, 09-65-04. Highly susceptible genotype, 15-22-47 recorded the lowest phenols (4.59 mg/g), while less susceptible genotype, 15-22-75 recorded highest phenol content (9.54 mg/g). Highly susceptible genotype, 15-22-47 recorded the lowest cellulose (7.60%), while less susceptible genotype, 10-14-16 recorded highest cellulose content (23.32%). The minimum of 0.16 per cent of tannin was recorded in highly susceptible genotype, 15-22-47. Whereas maximum of 0.41 per cent of tannin was recorded in less susceptible genotype, 10-14-16.

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