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THE IMPACT OF SOME PHYSIOMORPHIC CHARACTERS OF SUGARCANE GENOTYPES ON THEIR RESISTANCE AGAINST SUGARCANE PYRILLA, *Pyrilla perpusilla* Wlk. (Lophopidae: Homoptera)

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Field trials were conducted in the Research Area, Directorate of Sugarcane, Ayub Agricultural Research Institute, Faisalabad to study he physio-morphic characters of sugarcane resistance to the sucking pest *Pyrilla perpusilla.* Twenty genotypes of sugarcane were tested for their resistance susceptibility against *P. perpusilla,* as a preliminary screening experiment, during 2006. Based on the population-density count, 3 genotypes, viz., HSF-240, CPF-243 and S-2002-US-114 showing resistance responses, 3 genotypes viz. CPHS-35, S-2003-US-394 and S-2003-US-623 showing susceptible trends and 3 genotypes viz. S-2003-US-809, S-2002-US-140 and S-2002-US-104 exerting intermediate trends against the pest under test were selected for the final screening trials during 2007.The genotype S-2003-US-623, was found to be comparatively susceptible; whereas, HSF-240, showed resistance responses. The leaf-width and cane length showed a positive and significant correlation whereas the leaf-spine density had a significant negative effect with pest-population. The Leaf-length and Cane-Diameter did not show a significant correlation with the pest population.
Keywords: varietal resistance, physio-morphic characters, *Pyrilla perpusilla*, sugarcane genotypes

INTRODUCTION

Sugarcane leaf-hopper, *Pyrilla perpusilla* Wlk. (Lophopidae: Homoptera), commonly known as pyrilla, has recently become an endemic pest of various crops and is posing a serious threat to the sugar industry, in Pakistan (Khanzada, 1992).The nymphs and adults of this homopteran species are serious pests of sugarcane, as well as of other plants that desap them and thus affect their production (Kumar and Yadav, 2006).

The adults as well as nymphs, in addition to desaping the attacked plants seriously, excrete honey dew, which ultimately makes a good medium for the growth of black mould that ultimately reduces the photosynthetic activity of the leaves and the sugar yield up to 25%. The cane-juice becomes high in glucose, tunes insipid and if used for making gur gives a soggy mass, which does not solidify properly (Chaudhry and Ansari, 1988).

An early-infestation, during the grand growth period of cane, adversely affects the yield, while the late-infestation from September onwards, mostly affects the sucrose contents of cane, in the field (Puri and Sidharth, 2001). The farmers usually rely on insecticides, for a rapid control of this pest insect. This practice has created several subsidial problems such as pest resistance, resurgence of pest populations, outbreaks of secondary pests, destruction of beneficial insects, i.e. parasites, predators and pollinators, insecticide-residues in the food-chain, as well as environmental pollution and finally high cost for the control of resistant insect pest populations. The above mentioned hazards of insecticides have diverted the attention of scientists, to search for alternatives to overcome this complex situation. One of the possible solutions to this problem is the use of insect-resistant cultivars (Van der Harvae, 1979) that can additionally be used with other control strategies for the sustainable management of the pest. Resistance is often considered to depend upon a mechanism that consists mainly of two components; morphology and biochemistry (Dent, 1991).

Different scientists studied the physiomorphic basis of resistance to sucking pest, *Pyrilla perpusilla* across a wide genetic range of sugarcane cultivars. Some cultivars are least susceptible to the pest (less than three insects/leaf); whereas, others were found to be highly susceptible (above eight insects/leaf) (Choudhary *et al*., 1999). A Non significant correlation between the *Pyrilla perpusilla* population, and cane-diameter, cane-height, green leaves per cane, number of millable cane, commercial cane-sugar, percent brix and significantly positive correlation were observed

between leaf width and the pest population (Deepak *et al*., 1999). The most important features for the antibiotic- resistance are the spine-density and thickness of the phloem fiber-layer in the minor vascular bundle (Kumarasinghe *et al.,* 2001).The varieties with hard mid-rib, as well as erect and narrow leaves were less preferred by the top-borer and pyrilla (Madan, 2001).

Keeping the above account in view, the present study was designed not only to determine the comparative resistance/susceptibility, of twenty available commercial varieties as well as advanced genotypes of sugarcane against *P. perpusilla*, based on its population build-up with special reference to the impact of some physiomorphic features of the selected lines.

MATERIALS AND METHODS

The experiments were conducted in the field for two successive years, 2006 and 2007. Experiments were laid out in a Randomized Complete Black Design (RCBD), in the Research Area, Directorate of Sugarcane, Ayub Agricultural Research Institute, Faisalabad. The crop was sown in a north-west direction, for each experiment and the sets of two buds for each variety, were placed together, side by side, longitudinally.

***Preliminary screening during 2006*:** The test varieties consisted of HSF 240, CPF 243, S-2002-US-114, S-2003-US-165, SPF-213, SPF-234, CP-77-400, S-2002-US-637, S-2000-US-50, S-2003-US-809, S-2002-US-140, S-2002-US-104, CP-72-2086, S-2002-US-133, S-2002-US-447, HSF-242, HSF-245, CPHS-35, S-2003-US-394 and S-2003-US-623. These all varieties were sown on February 15, 2006. The experiment was repeated thrice, with a plot size of 13×3.05m having row to row distance of 0.76m; all the recommended agronomic practices were given to the crop during the experiment. However no plant protection measurements against the pest attack were taken.

Ten leaves were randomly selected from each plot, to check the population-density of the pest per leaf and the observations were taken on weekly basis. Three genotypes, each one representing the resistant, susceptible and intermediate lines, were selected for further experiments. Thus, nine genotypes were selected in total.

***Final screening during 2007*:** Nine genotypes of sugarcane, i.e., CPHS-35, S-2003-US-394, S-2003-US-623 (susceptible), S-2003-US=809, S-2002-US-140, S-2002-US-104 (intermediate), HSF 240, CPF 243 and S-2002-US-114 (resistant), were selected from the preliminary trials, during 2006, on the basis of population-density per leaf for a further study.

These were, sown on Feb 20, 2007, in three repeats. The size of plot was kept as 13 x 4.58 m and a row to row distance was maintained at 0.76 m. There were five rows in each plot for each variety. The data regarding the population of pyrilla were recorded on weekly basis. The data on physiomorphic plant-factors were studied from four other rows and correlated with the insect-pest population.

RESULTS AND DISCUSSION

***Preliminary screening during 2006*:** The data on the population of *P. perpusilla* (nymphs + adults), per leaf, on different genotypes of sugarcane were compared with a DMR Test, at P=0.05 (Table 1). The maximum population of *P. perpusilla,* was recorded to be 13.67, per leaf, on S-2003-US-623 and it differed, significantly, from that of all other genotypes. Genotype CPHS-35 had 13.01 individuals per leaf, and did not show a significant difference from those recorded on S-2003-US-394 and HSF-245 (13.14 and 12.78 individuals per leaf, respectively).

Data collection

The data, regarding the pyrilla –population, per leaf was recorded, randomly, throughout the season, consistently at an interval on 7+2 days starting form May, 2006-2007. The physio-morphic basis of restant were studied in the 9 selected genotypes. In these physio-morphic characteristics leaf –span density (cm2) was examined by taking four leaves, randomly, form different plants, from each plot. Each leaf –sheath was examined form different spots, under a sterio-microscope. Then the number of hair, were counted form an erea of one cm2. The leaf –weth (cm) of each leaf –blade, was measured form the central point whereas leaf –length (cm) of the total leaf –blade was measured form the 5, randomly, selected leaves, with the help of an ordinary measuring tap. The Can diameter (cm) was calculated, from the ground level to the plant-canopy, from five randomly selected plants with the help of an ordinary to the plant-canopy, from five randomly selected plants with the help of an ordinary measuring-tape.

The minimum population of *P. perpusilla* was 4.03 individuals per leaf, on HSF-240 and was statistically at par with that recorded on CPF-243 (4.30 individuals per leaf). The latter mentioned genotype also showed a non-significant difference from those observed on S-

2002-US-114 and S-2003-US-165 (4.39 and 4.54 insects per leaf, respectively). Genotypes S-2003-US-809 and S-2002-US-140 (with 9.15 and 9.41, individuals of *P. perpusilla* per leaf respectively) showed a non-significant variation, with each other and were categorized as intermediate. The latter mentioned figure, also showed a non- significant difference from those found on S-2002-US-104 and CP-72-2086 (9.52 and 9.57 individuals per leaf, respectively). The population of *P. perpusilla* was recorded to be 9.94, 11.13 and 12.04 individuals per leaf, on S-2002-US-133, S-1002-US-447 and HSF-242, respectively and it did not show a significant difference from one another. The population of *P. perpusilla* was observed to be 9.07, per leaf, on S-2000-US-50 and it had a significant variation with those found on all other genotypes. A non-significant variation was observed among SPF-213. SPF-234 and CP-77-400 had 8.44, 8.47 and 8.73 *P. perpusilla* per leaf, respectively.

Table 1. A comparison of the mean population of *pyrilla perpusilla,* per leaf, on various genotypes of sugarcane, during 2006.

Genotypes	Mean Population / Leaf
HSF 240	4.03 m *
CPF 243	4.30 lm *
S-2002-US-114	4.39 l *
S-2003-US-165	4.54 l
SPF-213	8.44 k
SPF-234	8.47 jk
CP-77-400	8.73 jk
S-2002-US-637	8.75 j
S-2000-US-50	9.07 l
S-2003-US=809	9.15 hi **
S-2002-US-140	9.41 gh **
S-2002-US-104	9.52 g **
CP-72-2086	9.57 g
S-2002-US-133	9.94 f
S-2002-US-447	11.13 e
HSF-242	12.04 d
HSF-245	12.78 c
CPHS-35	13.01 bc***
S-2003-US-394	13.14 b ***
S-2003-US-623	13.67 a ***
LSD at P = 0.05	0.2841

Means sharing similar letters, are not significantly different, at 5% probability.

* = Resistant, ** = Intermediate, ***** =** Susceptible

The latter mentioned figures also showed a non-significant difference with those recorded on S-2002-US-637, having 8.75 individuals per leaf. Keeping in view the above mentioned results, it can be concluded that genotypes HSF-240, CPF-243 and S-2002-US-114, showed a comparatively resistant response, with a minimum population of the pest, that ranged from 4.03 to 4.39 individuals per leaf; whereas, genotypes S-2003-US-623, S-2003-US-394 and CPHS-35 appeared to be comparatively susceptible genotypes, with a maximum population of the pest ranging from 13.01 to 13.67 individuals per leaf. Furthermore S-2003-US-809, S-2002-US-140 and S-2002-US-104, showed an intermediate response, with a population range of 9.15 to 9.52 individuals per leaf. These genotypes were selected for further screening trials in order to confirm the results obtained in the preliminary screening experiments.

***Final screening during 2007*:** Nine genotypes of sugarcane, 3 showing resistant (HSF-240, CPF-243 and S-2002-US-114); 3 showing susceptible (S-2003-US-623, S-2003-US-394 and CPHS-35) and 3 showing intermediate (S-2003-US-809, S-2002-US-140 and S-2002-US-104) responses, were tested for their resistance/susceptibility trends, against the *P. perpusilla,* on its population basis, during 2007.

The mean comparison of the data, regarding the population of *P. perpusilla,* per leaf, on various selected genotypes of sugarcane (Table 2) revealed that the genotype S-2003-US-623 had a maximum population of *P. perpusilla* and appeared to be comparatively susceptible with a population of 17.24 pests per leaf, which differed significantly from those observed in all other genotypes. The minimum population of the pest was recorded to be 4.84 individuals per leaf on HSF-240 and it showed a relatively resistant trend that did not differ significantly from that of 4.97 individuals per leaf, found on the genotype, CPF-243. Genotypes S-2002-US-114, S-2003-US-809, S-2002-US-140, S-2002-US-104, CPHS-35 and S-2003-US-394 showed a population of 5.64, 8.89, 9.58, 10.55, 15.49 and 16.19 individuals of *P. perpusilla* per leaf, respectively, that differed significantly from one another. From these results it was observed that the genotype S-2003-US-623 was found comparatively to be susceptible; on the other hand HSF-240 showed resistance responses with a maximum of 17.24 pests per leaf and a minimum of 8.84 pests per leaf respectively. Furthermore, it was also observed that all the genotypes showed a similar trend in response to the population of *P. perpusilla,* as was also observed during 2006, in the preliminary screening trials.

***Physio-morphic plant-characters*:** The various physio-morphic plant characters determined were leaf width, leaf length, leaf spines density, cane length and cane diameter. The objectives of these studies were to

determine the variations of these factors quantitatively among the selected genotypes and to calculate their impact on the population fluctuations of the pest by computing the data into simple correlations and multiple linear regression analysis. The results are presented, under the following sub-sections.

Table 2. A comparison of the mean population of *pyrilla perpusilla,* per leaf, on the selected genotypes of sugarcane, during 2007.

Genotypes	Mean Population / leaf
HSF-240	4.84 h
CPF-243	4.97 h
S-2002-US-114	5.64 g
S-2003-US-809	8.89 f
S-2002-US-140	9.58 e
S-2002-US-104	10.55 d
CPHS-35	15.49 c
S-2003-US-394	16.19 b
S-2003-US-623	17.24 a
LSD at P = 0.05	0.35

Means sharing similar letters are not significantly different at 5% probability.

***Leaf width (cm)*:** The data, regarding the leaf-width (cm) showed a significant difference ($P < 0.05$) in different selected genotypes of sugarcane. A comparison of the means for the data is presented in Table 3). It is evident from the results that the maximum leaf-width was recorded to be 6.16 cm on the leaves of CPHS-35 and it did not show a significant variation from a leaf-width of 4.84 cm on S-2003-US-623. The latter mentioned figure also showed a non-significant variation from the rest of the genotypes that ranged from a minimum of 3.80 to a maximum of 4.72 cm. From these results it was concluded that the genotypes CPHS-35 possessed a maximum leaf-width whereas, HSF-240 had the minimum (3.80 cm) leaf-width.

Leaf length (cm): The data regarding leaf-length in various selected genotypes of sugarcane revealed a significant difference ($P < 0.01$) among the genotypes. The means were compared with a DMR Test, at P= 0.05 level (Table 3). The genotype S-2002-US-104 showed a maximum leaf-length of 160.33 cm, which differed significantly from those observed in all other genotypes. The minimum leaf-length was recorded to be 121.67 cm in genotype S-2002-US-114 which showed significant variations from these of other genotypes. A non-significant difference was observed between HSF-240 and S-2003-US-623 with a leaf-length of 151 and 152.00 cm respectively. Similarly, the genotypes S-2002-US-140 and S-2003-US-394 with leaf-length of 142.00 and 143.33 cm respectively had a non significant difference with each other. The genotype CPF-243, S-2003-US-809, and CPHS-35, with a leaf-length of 147.67, 128.33 and 138.33 cm, respectively showed a significant variation with one another. From these results it was concluded that the genotype S-2002-US-104 had the maximum leaf-length whereas, S-2002-US-114 had a minimum one.

Leaf spine density (cm^2): The data, pertaining to the leaf-spine density on different selected genotypes revealed a highly significant variation among genotypes. The means were compared by a DMR Test at P=0.05 (Table 3). It is clear from the results that the genotype CPF-243 showed a maximum leaf-spine density, i.e., 31.37 $cm^{2,}$ which differed significantly from the spine densities of 30.80 and 30.27 cm^2 in the cases of HSF-240 and S-2002-US-114 respectively. The minimum spine-density was recorded to be 5.10 cm^2 on genotype S-2003-US-394 and was found to be at par statistically with that of 5.57 cm^2 and 6.13 cm^2, on S-2003-US-623 and CPHS-35 respectively. The genotypes S-2003--US-809, S-2002-US-104 and S-2002-US-140 possessed the leaf-spine densities of 21.57 cm^2, 19.03 cm^2 and 18.80 cm^2, respectively. The later mentioned two genotypes did not show a significant difference with each other. From these results it was concluded that the genotypes S-2003-US-394 possessed the lowest leaf-spines density of 5.10cm^2 and the genotype CPF-243 had a maximum leaf-spine density of 31.37 $cm^{2,}$ on its leaves.

Cane length (m): The data relating to the cane- length in different selected genotypes of the sugarcane revealed a significant difference among the genotypes. The means were compared by a DMR Test, at P=0.05 (Table 3). The genotypes S-2002-US-104 showed a maximum cane-length of 3.56 m which differed, significantly from that observed in all other genotypes. The minimum cane-length i.e., 2.27 m was recorded in genotype CPF-243 and it did not show a significant difference from that of 2.33 m, in genotypes S-2002-US-140. The later mentioned genotypes also showed a non-significant difference with those observed in HSF-240 with a cane-length of 2.37 meters. A non-significant difference was also observed between CPHS-35 and S-2003-US-394 with a cane-length of 2.90 m and 2.89 m respectively. Similarly, a cane-length of 2.58m and 2.55m observed in genotypes S-2003-US-809 and S-2003-US-623 respectively also showed a non-significant difference, from one another. The genotypes S-2002-US-114 showed a cane-length of 2.67m and it differed significantly from those observed in all other genotypes. From these results it

Table 3. A comparison of the means for different physio-morphic characters of various selected genotypes of sugarcane.

Name of Genotypes	Leaf width (cm)	Leaf Length (cm)	Leaf Spines Density (cm^2)	Cane Length (m)	Cane Diameter (cm)
HSF-240	3.80 b	151.00 b	30.80 a	2.37 e	2.47 c
CPF-243	3.82 b	147.67 c	31.37 a	2.27 f	2.56 b
S-2002-US-114	3.92 b	121.67 g	30.27 a	2.67 c	2.50 c
S-2003-US-809	4.43 b	128.33 f	21.57 b	2.58 d	2.49 c
S-2002-US-140	4.51 b	142.00 d	18.80 c	2.33 ef	2.61 b
S-2002-US-104	4.58 b	160.33 a	19.03 c	3.56 a	2.68 a
CPHS-35	6.16 a	138.33 e	6.13 d	2.90 b	2.45 c
S-2003-US-394	4.72 b	143.33 d	5.10 d	2.89 b	2.49 c
S-2003-US-623	4.84 ab	152.00 b	5.57 d	2.55 d	2.49 c
LSD at 5%	0.13	3.08	1.89	0.07	0.05

Means sharing similar letters are not significantly different, at 1% level of probability

was concluded that the genotypes S-2002-US-104 showed a maximum cane-length whereas the genotype CPF-243, had a minimum cane-length.

Cane-diameter (cm): The data relating to the cane-diameter revealed a highly significant difference among the genotypes. The means were compared by a DMR Test at P-0.05 (Table 3). The maximum cane-diameter was recorded to be 2.68 cm in genotypes S-2002-US-104 and it differed significantly from those observed in all other genotypes. The minimum cane-diameter was observed to be 2.45 cm on genotypes CPHS-35 and it did not show a significant difference from a cane-diameter of 2.47, 2.49, 2.49, 2.49, and 2.50 cm in the cases of HSF-240, S-2003-US-809, S-2003-US-394, S-2003-US-623 and S-2002-US-114 respectively. A non-significant variation was also found to exist between CPF-243 and S-2002-US-140 with a cane-diameter of 2.56 and 2.61 cm respectively. From these results it was concluded that genotype S-2002-US-104 showed a maximum cane-diameter 2.68 cm whereas CPHS-35 had a minimum cane-diameter of 2.45 cm.

Role of Physio-morphic plant-characters in the expression of resistance

***Correlation coefficient values*:** The results pertaining to the correlation coefficient values between the population of *P. perpusilla* and physio-morphic plant-characters are given in Table 4. It was evident from the results that the leaf-width showed a positive and significant correlation (P<0.01) with the population of *P. perpusilla* with an r-value of 0.644. The leaf-spine had a significant negative effect on the population of the pest with an r-value of 0.978. Positive and significant correlation (P<0.05) between pest-population and cane-length was observed with a correlation coefficient value of 0.428 as against the Leaf-length and Cane-diameter that did not show a significant correlation with the pest population.

Table 4. The correlation coefficient (r-values) between the population of *pyrilla perpusilla* and different phsio-morphic characters of selected genotypes of sugarcane.

PHYSIO-MORPHIC CHARACTERS	r-value
Leaf Width	0.644 **
Leaf Length	0.187
Leaf Spine-Density	-0.978 **
Cane length	0.428 *
Cane Diameter	-0.166

* = Significant at P ≤ 0.05; ** Significant at P ≤ 0.01.

Multivariate linear regression models: The results regarding the Multivariate Linear Regression analysis along with the coefficient of determination values between the physio-morphic plant-characters and the population of *P. perpusilla* are given in Table 5. The results revealed that all the regression models showed a significant impact on the population of the pest. Leaf-width and leaf-spine showed the maximum impact on the population fluctuations of the pest i.e., 41.5 and 51.9% respectively. Leaf-length showed 2.3% role in the population fluctuations of the pest whereas the cane-length and cane-diameter showed 0.7 and 0.5% role in the population fluctuations of the pest. The 100 R^2 values were observed to be 96.9 when the effect of all physio-morphic plant-characters was computed together. From these results it was concluded that leaf-spine character was the most important physiomorphic factor, followed by the leaf-width.

Table 5. A multivariate analysis of variance, between the physio-morphic characters and the population of *pyrilla perpusilla.*

Regression Equation	R^2	$100R^2$	Impact (%)
Y = -2.2795+2.4606x1	0.415	41.5	41.5
Y = -4.8860+2.4303x1+0.2239x2	0.438	43.8	2.3
Y = 4.6756+0.1235x1+0.03568x2-0.5167x3	0.957	95.7	51.9
Y = 3.9776+0.04753x1+0.00937x2-0.507x3+0.6425*x4	0.964	96.4	0.7
Y = 0.4365+0.00915x1-0.0371x2-0.5322x3+0.4254x4+2.6868x5	0.969	96.9	0.5

Where X1 = Leaf width (cm); X2 = Leaf Length (cm); X3 = Leaf Spines Density (cm^2); X4 = Cane Length (m) and X5 = Cane Diameter (cm)

The present findings are in conformity with those of Kumarasinghe *et al*. (2001) who stated that spine-density is the most important character for anti-biotic resistance, against *P. perpusilla*. Similarly the present findings can partially be compared with those of Deepak *et al*. (1999) who reported that cane-diameter and cane-length showed a non- significant correlation with the leaf-hopper population as against the present studies which showed that the cane-diameter showed a non-significant while cane-length showed a significant positive correlation with the pest-population. The present studies are also in line with those of Madan (2001) who observed that the varieties with hard mid-rib, erect and narrow leaves are less preferred by Pyrilla like the present findings that showed that the varieties with minimum leaf width are resistant and less preferred by pyrilla in comparison to the broad leaf varieties.

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