Research Article

Population Trend of Sugarcane Leafhopper *Pyrilla perpusilla* on Different Sugarcane Varieties with Biotic and Abiotic Factors

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Abstract | *Pyrilla perpusilla* (Walker) is one of the devastating pests which decrease yield directly and indirectly of sugarcane crop. For the safe management of *P. perpusilla,* field experiments were conducted to find the population of *Pyrilla perpusilla* on 12 different sugarcane varieties under field conditions at two different districts Charsadda and district Dera Ismail Khan of Khyber Pakhtunkhwa. Plot size 36×16 m (length × width) was selected in both localities for the cultivation of sugarcane varieties (CP77/400, Jhang 59, 2086, US-633, YT-55, CPF-252, CPF-246, CPF-251, CPF-247, CPF-250, CPF-248, and CPF-249) in Feb 2020. Each variety was planted in sub-plot size 3×2 meters having 3 rows and 5plants/row in randomized complete block design (RCBD) with three replications. The data was recorded from Mar-Nov from fresh and ratoon crops of the year 2020 and 2021, respectively. The leaves (top, middle, and bottom) of five plants in each subplot was observed randomly for data collection every fortnight in all replications. The total mean population of *Pyrilla perpusilla* (eggs cluster and nymphs/adults) was recorded from the leaves of the plants. The experimental results were of the view that could be used to conclude the research that the different varieties have different behaviour towards hosting the *P. perpusilla*. The population *Pyrilla perpusilla* (eggs clusters and nymphs/adults) were found highest on CPF-252 while least population of *P. perpusilla* was recorded on CPF-249 in both location and both years of the study (2020-2021) with its peak activity in the month of August. Significantly, positive correlation was recorded between *P. perpusilla* (eggs clusters and nymphs/adults) population infestation and average abiotic factors (temperature, humidity and rainfall). The correlation between leaf length and leaf width with *P. perpusilla* (eggs clusters and nymphs/adults) was significantly positive, the correlation of *P. perpusilla* (eggs clusters and nymphs/adults) with cane length was non-significant but positive while negative non-significant correlation was found between *P. perpusilla* (eggs clusters and nymphs/adults) population and cane diameter. The population of *P. perpusilla* on sugarcane variety CPF-249 was comparatively less which can be combine in future IPM programmes for the suppression of *P. perpusilla* infestation.

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Introduction

Pyrilla perpusilla Walker (Lophopidae: Homoptera), also known as Sugarcane pyrilla, has recently been emerged as an endemic pest of several crops in Pakistan, posing a serious threat to the sugar industry (Khanzada, 1992). This homopteran species (nymphs and adults) are important pest of sugarcane and other plants, killing them and reducing their productivity (Kumar and Yadav, 2006). Honey dew is excreted by adults and nymphs, creating an excellent habitat for the growth of black mould, which reduces the photosynthetic activity of the leaves and sugar yield by up to 25% (Chaudhry and Ansari, 1988). Early infestations of *P. perpusilla* which occur during the cane's growth period, reduce production, but late infestations, which occur after September, affect the sucrose content of the cane in the field (Puri and Sidharth, 2001).

Insecticides are commonly used by farmers to quickly eradicate this annoyance pest *P. perpusilla* but pest resistance, resurgence of pest populations, outbreaks of secondary pests, destruction of beneficial insects such as parasites, predators, and pollinators, insecticide residues in the food chain, environmental pollution, and finally, high costs associated with controlling resistant insect pest populations are all issues that have arisen because of this practise. The above-mentioned insecticide hazards have turned scientists attention to finding alternatives to this tough situation (Van der Harvae, 1979). Insect-resistant cultivars are one viable answer to this problem, which can also be used in concert with other control strategies to assure the pest's long-term management. Resistance is often attributed to a mechanism that consists primarily of two elements: morphology and biochemistry (Dent, 1991). Several researchers investigated the physiomorphic basis of resistance to *Pyrilla perpusilla*, a sucking pest, in a wide genetic range of sugarcane cultivars. Some cultivars are more resistant to the pest, while others are more vulnerable (Chaudhary *et al*., 1999). The *Pyrilla perpusilla* population was found to have a non-significant relationship with cane diameter, height, number of green leaves per cane, malleable cane, commercial cane sugar, and percent brix, while leaf width was found to have a significantly positive relationship with the pest population (Deepak *et al*., 1999). Varieties having a strong midrib, as well as erect and narrow leaves, were detested by the top-borer and *Pyrilla perpusilla* (Madan, 2001).

Pyrilla perpusilla dies for a variety of reasons in a variety of temperatures and regimes. Numerous studies have been conducted to determine how the pest's population varies over time. The pest was active throughout the year in Pakistan, completing 3–4 generations. It was most active throughout the months of July to September (Shah and Saleem, 2002). This is what happened in Sri Lanka, where the temperature changes just slightly each year. There were two peak populations before to the two monsoon seasons (Kumarasinghe and Ranasinghe, 1988). These investigations indicate that fluctuations in the pest's population appear to be related to changes in the weather.

Different weather elements play a key impact in the regulation of *P. perpusilla* population levels at different times of the year. Temperatures of 29.4 degrees Celsius and relative humidity (RH) of 75.84 percent, according to Gupta and Ahmed (1983), are the most favourable for *P. perpusilla* optimal growth and development. Temperatures greater than 43 degrees Celsius and less than 9.4 degrees Celsius are conducive to pest growth inhibition. According to Rajak *et al*. (1987), high humidity is associated with a low Pyrilla population, although Patil and Hapase (1992) found the inverse to be the case. According to Ganehiarachchi and Fernando (2008), the quantity of *P. perpusilla* produced is adversely related to rainfall and humidity but is positively associated to the minimum temperature. The first and most important step in developing environmentally friendly pest management solutions for sugarcane is to better understand the pest population with resistant from various sugarcane varieties and its interactions with abiotic and biotic elements in the crop.

The novelty of the study is that how the population of *P. perpusilla* varied on different sugarcane varieties over time, as well as the relationship between these changes and the abiotic factors at District (Charsadda and Dera Ismail Khan) for the first time in Khyber Pakhunkhwa. The use of resistant cultivars in sugarcane fields will help to reduce direct *P. perpusilla* damage and sooty moulds and enhance production yield, which is valuable to develop a successful integrated pest management (IPM) programme for the *P. perpusilla*.

Materials and Methods

Population of sugarcane leafhopper Pyrilla perpusilla on different sugarcane varieties under field conditions

The research studies were conducted to find the population of *Pyrilla perpusilla* on 12 different sugarcane varieties under field conditions at two different districts of Khyber Pakhtunkhwa, during 2020-2021.

Experimental sites

For field experiments area was selected at Agriculture Research Station, Harichand, district Charsadda (34.2165° N, 71.7148° E) and on farmer field, district D.I. Khan (31.7448° N, 70.6217° E).

Field preparation

Plot size 36×16 m (length × width) was selected in both localities for the cultivation of sugarcane varieties (CP77/400, Jhang 59, 2086, US-633, YT-55, CPF-252, CPF-246, CPF-251, CPF-247, CPF-250, CPF-248, and CPF-249) in Feb 2020. Each variety was planted in sub-plot size 3×2 meters having 3 rows and 5plants/row. These varieties were obtained from SCRI, Mardan, and Ayub Agriculture Research Institute, Faisalabad, and was sown in a randomized complete block design (RCBD) with three replications. All the agronomic practices were kept constant throughout the growing season. Water was applied when necessary. No pesticides were applied in both locations.

Data collections

The data was recorded from Mar-Nov from fresh and ratoon crops of the year 2020 and 2021, respectively from both mentioned sites. The leaves (top, middle, and bottom) of five plants in each subplot was observed randomly for data collection every fortnight in all replications. The total mean population of *Pyrilla perpusilla* (eggs cluster and nymphs/adults) was recorded from the leaves of the plants (Ullah and Mahmood, 2007). The mean population was calculated by the following formula.

$$\text{Mean number of eggs cluster, Nymph/adults} = \frac{Mean\ number\ of\ eggs, Nymph/adults}{Total\ number\ of\ observed\ leaves}$$

Statistical analysis

All the recorded data was statistically analysed by statistics software (Statistix 8.1) and the mean population of each month was compared by LSD test @ 5% of probability (Gomez and Gomez, 1984).

Correlation of mean population of Pyrilla perpusilla with Biotic and Abiotic factors

The recorded mean population of *Pyrilla perpusilla* (mentioned earlier) of each mentioned variety was correlated with biotic factors (plant morphological characters) i.e., leaf length (cm), leaf width (cm), cane length, cane diameters, and daily recorded metrological data regarding various abiotic factors (weather parameters) i.e., relative humidity, temperature (Min and Max) and rain fall from the meteorological observatory of districts (Charsadda) from the arrival of the pest (*Pyrilla perpusilla*) till the end of the experimental period in both the areas of the research field.

Analysis of recorded data

All the recorded data was analysed through statistical software IBM-SPSS using Pearson's Correlation coefficient @ 0.01 probability.

Results and Discussion

Mean number of P. perpusilla (eggs clusters and nymphs/adults) leaf^{-1} on different sugarcane varieties at Charsadda during 2020-21

The results present in table-1 shows that the mean number of *Pyrilla perpusilla* (egg clusters leaf^{-1}) on different sugarcane varieties during 2020 was statistically significant at Charsadda. The mean number of *Pyrilla perpusilla* (egg clusters leaf^{-1}) on different sugarcane varieties was maximum (3.78 clustersleaf^{-1}) on sugarcane variety CPF- 252 followed by US-633, CPF-247 and CPF-248 with (3.31, 3.28 and 2.90 eggs cluster leaf^{-1}), respectively. The minimum (1.96 egg cluster leaf^{-1}) was recorded on sugarcane variety CPF-249. The mean number of *Pyrilla perpusilla* (egg clusters leaf^{-1}) on different sugarcane varieties was statistically significant during 2021. The mean number of *P. perpusilla* (eggs clusters leaf^{-1}) on different sugarcane varieties was minimum (2.08 eggs clusters leaf^{-1}) were recorded on sugarcane variety CPF-249 followed by CP 77/400, CPF-246 and YT-55 with mean number of 2.15, 2.26, and 2.27 eggs clusters leaf^{-1}, respectively (Table 2). While the maximum mean number (3.98 eggs clusters leaf^{-1}) were recorded on sugarcane variety CPF-252.

The mean number of *Pyrilla perpusilla* (nymphs/adults leaf^{-1}) on different sugarcane varieties at Charsadda shows statistically significant difference, during 2020 (Table 1). The highest mean number (15.48 nymphs/

adults leaf^{-1}) were noted on sugarcane variety CPF-252 followed by sugarcane variety US-633, CPF-247, and CPF-250 with 14.76, 14.50 and 11.34 (nymphs/adults leaf^{-1}), respectively. While the lowest mean number (7.89 nymphs/adults leaf^{-1}) were recorded on sugarcane variety CPF-249. Similarly, during 2021 the mean number of *Pyrilla perpusilla* (nymphs/adults leaf^{-1}) on different sugarcane at Charsadda was also statistically significant. The minimum mean number (8.32 nymphs/adults leaf^{-1}) was recorded on sugarcane variety CPF-249 followed by CP-77/40, CPF-246 and YT-55 with (8.58, 9.64 and 10.22 nymphs/adults leaf^{-1}), respectively. While the maximum mean number (16.34 nymphs/adults leaf^{-1}) were recorded on sugarcane variety CPF-252.

Table 1: *Mean number of P. perpusilla (eggs clusters and nymphs/adults) leaf^{-1} on different sugarcane varieties at Charsadda during 2020-21.*

Sugarcane varieties	Eggs cluster leaf^{-1}		Nymphs/adults leaf^{-1}	
	2020	2021	2020	2021
CP77/400	2.02 gh	2.15 c	8.09 d	8.58 d
Jhang 59	2.50 de	2.6 de	10.36 bc	10.96 bc
2086	2.27 e-g	2.40 e-g	9.95 bc	10.47 bc
US-633	3.31 b	3.49 b	14.76 a	15.55 a
YT-55	2.14 f-h	2.27 f-h	9.68 c	10.22 c
CPF-246	2.14 f-h	2.26 f-h	9.14 cd	9.64 cd
CPF-247	3.28 b	3.46 b	14.50 a	15.29 a
CPF-248	2.90 c	3.06 c	9.68 c	10.25 c
CPF-249	1.96 h	2.08 h	7.89 d	8.32 e
CPF-250	2.76 cd	2.91 cd	11.34 b	11.94 b
CPF-251	2.35 ef	2.48 ef	9.78 c	10.38 c
CPF-252	3.76 a	3.98 a	15.48 a	16.34 a
LSD	0.6797	0.7000	1.4373	1.5175

Means followed by different letter(s) are significantly different from each other ($p \leq 0.05$).

Mean number of P. perpusilla (eggs clusters and nymphs/adults) leaf^{-1} on different sugarcane varieties at Dera Ismail Khan during 2020-21

The results regarding the mean number of *Pyrilla perpusilla* (eggs and nymphs/adults leaf^{-1}) on different sugarcane varieties during 2020-21 at Dera Ismail Khan are present in Table 2 which shows statistical significant difference. During 2020, the mean number of *Pyrilla perpusilla* (egg clusters leaf^{-1}) shows that the highest mean number (3.61 egg clusters leaf^{-1}) were recorded on sugarcane variety CPF-252, followed by CPF-247 (3.14 egg clusters leaf^{-1}), CPF-250 (2.64 egg clusters leaf^{-1}) and Jhang-59 (2.38 egg clusters leaf^{-1}). While, the lowest mean number (1.88 egg Clusters leaf^{-1}) were recorded on sugarcane variety CPF-249. The results regarding 2021 at Dera Ismail Khan, shows that the mean number of *P. perpusilla* (egg clusters leaf^{-1}) were maximum (3.86 egg clusters leaf^{-1}) on sugarcane variety CPF-252. Followed by CPF-247, US-633 and CPF-250 with (3.37, 3.36 and 2.83 egg clusters leaf^{-1}), respectively. While, the minimum mean number (2.02 egg clusters leaf^{-1}) were recorded on sugarcane variety CPF-249.

Table 2: *Mean number of P. perpusilla (eggs cluster and Nymphs/adults) leaf^{-1} on different sugarcane varieties at Dera Ismail Khan during 2020-21.*

Sugarcane varieties	Eggs cluster leaf^{-1}		Nymphs/Adults leaf^{-1}	
	2020	2021	2020	2021
CP77/400	1.92 g	2.12 f	7.79 d	8.29 d
Jhang 59	2.38 de	2.54 d	9.94 bc	10.56 bc
2086	2.12 e-g	2.27d-f	9.56 bc	10.10 bc
US-633	3.13 b	3.36 b	14.18 a	14.99 a
YT-55	2.13 e-g	2.29d-f	9.28 c	9.84 c
CPF-246	2.05 fg	2.19 ef	8.78 cd	9.30 cd
CPF-247	3.14 b	3.37 b	13.92 a	14.74 a
CPF-248	2.75 c	2.94 c	9.30 c	9.88 c
CPF-249	1.88 g	2.02 g	7.50 e	8.01 e
CPF-250	2.64 cd	2.83 c	10.88 b	11.50 b
CPF-251	2.23 ef	2.39 de	9.40 c	10.03 bc
CPF-252	3.61 a	3.86 a	14.96 a	15.75 a
LSD	0.6515	0.6912	1.3602	2.9182

Means followed by different letter(s) are significantly different from each other ($p \leq 0.05$).

Moreover, the mean number of *Pyrilla perpusilla* (nymphs/adults leaf^{-1}) on different sugarcane varieties at Dera Ismail Khan also shows significant difference during 2020-21 (Table 2). In 2020, the maximum mean number (14.96 nymphs/adults leaf^{-1}) were recorded on sugarcane variety CPF-252, followed by CPF-247, CPF-250 and Jhang-59 with 13.92, 10.88 and 9.94 nymphs/adults leaf^{-1}, respectively. While the minimum mean number (7.50 nymphs and adults leaf^{-1}) were recorded on sugarcane variety CPF-249. In 2021, the overall mean number of *Pyrilla perpusilla* (nymphs/adults leaf^{-1}) on different sugarcane varieties (Table 2) was statistically significant. The maximum mean number (15.75 nymphs/adults leaf^{-1}) were recorded on sugarcane variety CPF-252, followed by US-633, CPF-247 and CPF-250 with 14.99, 14.74 and 11.50 nymphs/adults leaf^{-1}, respectively. While the minimum mean number (8.1 nymphs/adults leaf

[1]) were recorded on sugarcane variety CPF-249.

Variation in mean number of Pyrilla perpusilla (egg clustres and nymph/adult leaf[-1]) with abiotic factors at Charsadda, 2020

The comparison of means data, regarding the *P. perpusilla* (egg clusters and nymph/adult leaf[-1]), at various months of observation with a biotic factor, on sugarcane during 2020 at Charsadda are presented in Figure 1. The results revealed that during March mean number of *P. perpusilla* were (0.92 egg clustersleaf[-1] and 2.45 nymph / adult leaf[-1]) with max. temp (23.4 ˚C), min. temp (11.9 ˚C), average temp (17.65 ˚C), R.H (47 %) and rain fall (72 mm). The mean number of *P. perpusilla* significantly ascend during the months of April (1.31 egg clustersleaf[-1] and 2.89 nymph and adult leaf[-1]), May (1.82 egg clustersleaf[-1] and 5.81 nymph/adult leaf[-1]) June (2.23 egg clusters leaf[-1] and 11.49 nymph/adult leaf[-1]) and July (3.92 egg clustersleaf[-1] and 16.89 nymph/adult leaf[-1]) with variations in a biotic factors. In August the peak (4.19 egg clustersleaf[-1] and 19.08 nymph/adult leaf[-1]) of were recorded with max. temp (34.3˚C), min. temp 24.3, average temp (29.3 ˚C), R.H (56 %) and rain fall (144 mm). After wards, decline trend was recorded in the mean number of *P. perpusilla* in month of September (4.20 egg clustersleaf[-1] and 17.2 nymph and adult leaf[-1]), October (2.87 egg clustersleaf[-1] and 13.26 nymph/adult leaf[-1] and November (2.29 egg clusters leaf[-1] and 8.92 nymph/adult leaf[-1]).

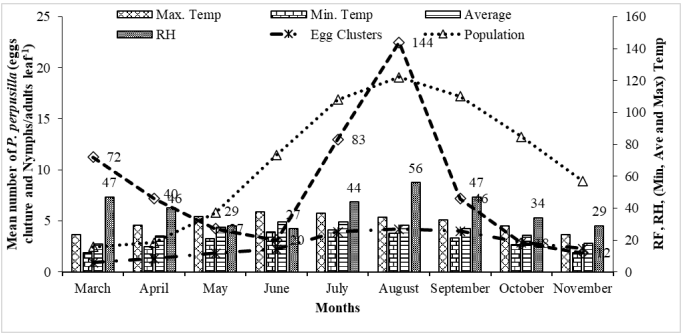

Figure 1: *Variation in mean number of Pyrilla perpusilla (egg clusters and nymph/adult leaf[-1]) with abiotic factors at Charsadda, 2020.*

Variation in mean number of Pyrilla perpusilla (egg clusters and nymph/adult leaf[-1]) with abiotic factors at Charsadda, 2021

The comparison of means data, regarding the *P. perpusilla* (egg clusters and nymph/adult leaf[-1]), at various months of observation with a biotic factors on sugarcane during 2021 at Charsadda are presented in Figure 2. The results revealed that during March mean number of *P. perpusilla* were (1.14 egg clusters leaf[-1] and 2.61 nymph/adult leaf[-1]) with max. temp (22.8 ˚C), min. temp (11.7 ˚C), average temp (17.3 ˚C), R.H (47 %) and rain fall (63 mm). The mean number of *P. perpusilla* significantly ascend during the months of April (1.38 egg clusters leaf[-1] and 3.04 nymph/adult leaf[-1]), May (1.90 egg clusters leaf[-1] and 6.01 nymph/adult leaf[-1]), June (2.33 egg clusters leaf[-1] and 11.98 nymph/adult leaf[-1]) and July (4.16 egg clustersleaf[-1] and 17.77 nymph/adult leaf[-1]) with variations in a biotic factors. In August the peak (4.45 egg clusters leaf[-1] and 19.76 nymph/adult leaf[-1]) were recorded with maximum temp (33.9 ˚C), min. temp 24.5, average temp (29.2 ˚C), R.H (59 %) and rain fall (124 mm). After wards, significant decline trend was recorded in the mean number of *P. perpusilla* in month of September (4.22 egg clustersleaf[-1] and 17.99 nymph/adult leaf[-1]), October (2.95 egg clusters leaf[-1] and 14.43 nymph/adult leaf[-1] and November (2.35 egg clusters leaf[-1] and 9.88 nymph/adult leaf[-1]).

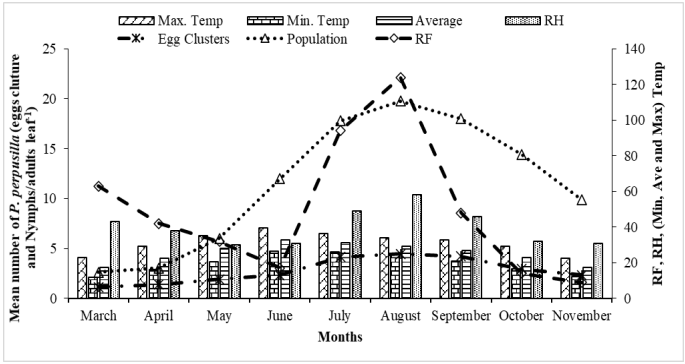

Figure 2: *Variation in mean number of Pyrilla perpusilla (egg clusters and nymph/adult leaf[-1]) with abiotic factors at Charsadda, 2021.*

Variation in mean number of Pyrilla perpusilla (egg clusters and nymph/adult leaf[-1]) with abiotic factors at Dera Ismail Khan, 2020

The comparison of means data regarding the *P. perpusilla* (egg clusters and nymph/adult leaf[-1]), at various months of observation with a biotic factors, on sugarcane during 2020 at DI Khan are presented in Figure 3. The results revealed that during March mean number of *P. perpusilla* were (0.82 egg clusters leaf[-1] and 2.30 nymph/adult leaf[-1]) with max. temp (31.1 ˚C), min. temp (17.2 ˚C), average temp (24.6 ˚C), R.H (65 %) and rain fall (32 mm). The mean number of *P. perpusilla* significantly ascend during the months of April (1.26 egg clusters leaf[-1] and 2.72 nymph/adult leaf[-1]), May (1.74 egg clusters leaf[-1] and 5.82 nymph/adult leaf[-1]) June (2.12 egg clusters leaf[-1] and 11.00 nymph/adult leaf[-1]) and July (3.73 egg

clusters leaf^{-1} and 16.16 nymph/adult leaf^{-1}) with variations in a biotic factors. In August the peak (4.02 egg clusters leaf^{-1} and 18.75 nymph/adult leaf^{-1}) of were recorded with max. temp (38.9) ˚C, min. temp 24.4, average temp (30.4 ˚C), R.H (74%) and rain fall (113 mm). After wards, significant decline trend was recorded in the mean number of *P. perpusilla* in month of September (3.78 egg clusters leaf^{-1} and 16.59 nymph/adult leaf^{-1}), October (2.78 egg clustersleaf^{-1} and 12.62 nymph/adult leaf^{-1} and November (2.22 egg clusters leaf^{-1} and 8.46 nymph/adult leaf^{-1}).

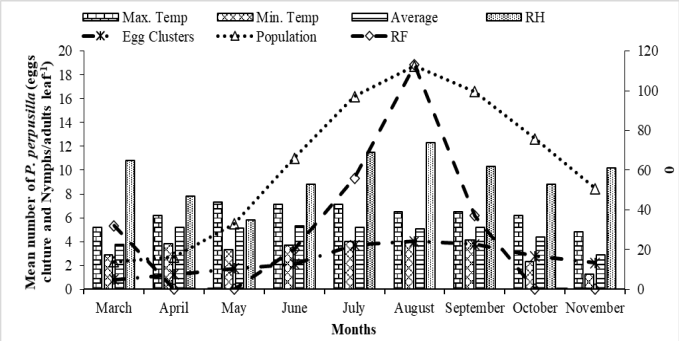

Figure 3: *Variation in mean number of Pyrilla perpusilla (egg clusters and nymph/adult leaf^{-1}) with abiotic factors at Dera Ismail Khan, 2020.*

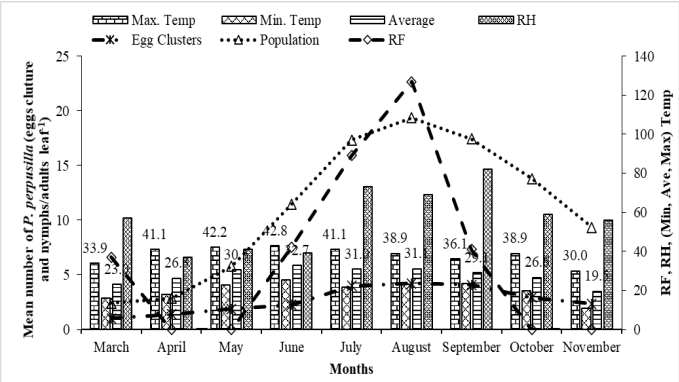

Figure 4: *Variation in mean number of Pyrilla perpusilla (egg clusters and nymph/adult leaf^{-1}) with abiotic factors at Dera Ismail Khan, 2021.*

Variation in mean number of Pyrilla perpusilla (egg clusters and nymph/adult leaf^{-1}) with abiotic factors at Dera Ismail Khan, 2021

The comparison of means data, regarding the *P. perpusilla* (egg clusters and nymph/adult leaf^{-1}), at various months of observation with a biotic factors, on sugarcane during 2021 at DI Khan are presented in Figure 4. The results revealed that during March mean number of *P. perpusilla* were (1.08 egg clusters leaf^{-1} and 2.41 nymph/adult leaf^{-1}) with max. temp (33.9 ˚C), min. temp (16.0 ˚C), average temp (23.0 ˚C), R.H (57 %) and rain fall (37 mm). The mean number of *P. perpusilla* significantly ascend during the months of April (1.39 egg clusters leaf^{-1} and 2.84 nymph/adult leaf^{-1}), May (1.88 egg clusters leaf^{-1} and 5.79 nymph/adult leaf^{-1}) June (2.26 egg clusters leaf^{-1} and 11.44 nymph/adult leaf^{-1}) and July (3.97 egg clusters leaf^{-1} and 17.34 nymph/adult leaf^{-1}) with variations in a biotic factors. In August the peak (4.08 egg clusters leaf^{-1} and 19.36 nymph/adult leaf^{-1}) of were recorded with max. temp (38.9) ˚C, min. temp 23.00, average temp (31.1 ˚C), R.H (74%) and rain fall (127 mm). After wards, significant decline trend was recorded in the mean number of *P. perpusilla* in month of September (4.07 egg clusters leaf^{-1} and 17.43 nymph/adult leaf^{-1}), October (2.92 egg clustersleaf^{-1} and 13.81 nymph and adult leaf^{-1} and November (2.34 egg clustersleaf^{-1} and 9.33 nymph and adult leaf^{-1}).

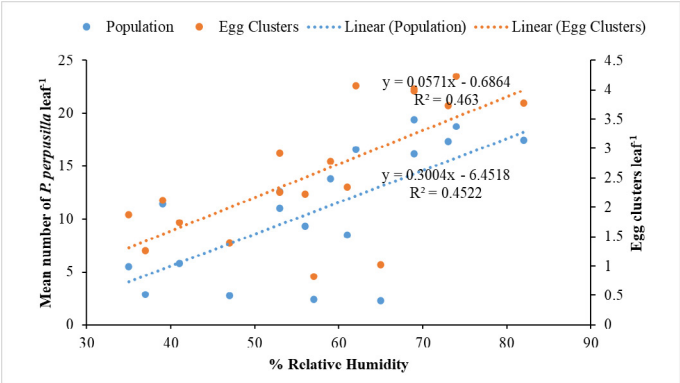

Figure 5: *Relation between relative humidity and mean number of P. perpusilla leaf^{-1}.*

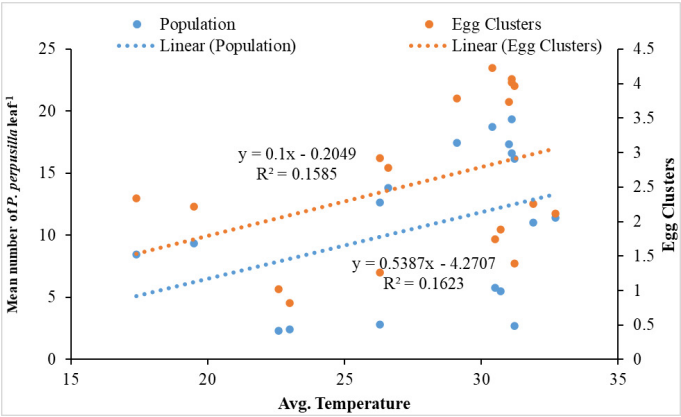

Figure 6: *Relation between relative Avg. Temperature and mean number of P. perpusilla leaf^{-1}.*

Correlation between mean number of Pyrilla perpusilla (egg clusters and nymph/adult leaf^{-1}) with abiotic factors (Relative humidity, average temperature and rainfall)

The correlations between mean number of *Pyrilla perpusilla* (egg clusters and nymph/adult leaf^{-1}) with abiotic factors are present in Figures 5, 6 and 7 which shows a significant positive correlation. The increase in relative humidity increases the *P. perpusilla* (nymph/adult leaf^{-1}) as well as their capacity to lay eggs with

r^2= 0.45 and 0.47, respectively (Figure 5). The increase in average temperature also show positive correlation between *P. perpusilla* ((nymph/adult leaf^{-1}) r^2 =0.16 and eggs leaf^{-1} r^2 =0.15 (Figure 6). Moreover, positive correlation is found between mean number of *Pyrilla perpusilla* (egg clusters, nymph/adult leaf^{-1}) with r^2 = 0.44 and 0.45, respectively, with rainfall (Figure 7).

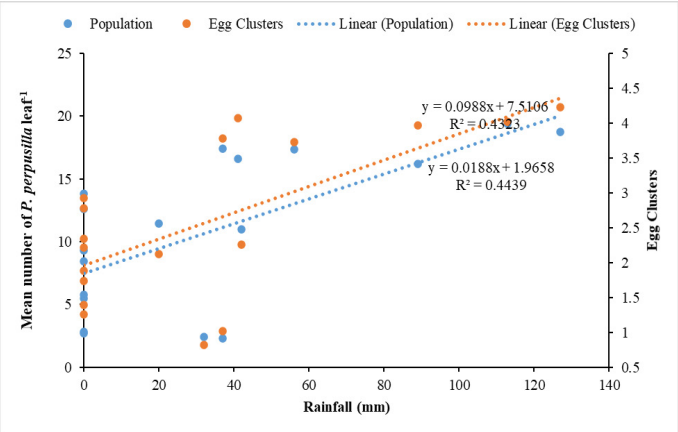

Figure 7: *Relation between Rainfall (mm) and mean number of P. perpusilla leaf^{-1}.*

Variation in leaf length of different sugarcane varieties at Charsadda and Dera Ismail Khan (DI Khan) during 2021-22

The variation in leaf length of different sugarcane varieties is presented in Figure 8. It can be elaborated from the results that there is significant variation in leaf length of different sugarcane varieties. Maximum leaf length (69.00 cm) was recorded from CPF-247 at DI Khan during 2020 followed by CPF-252 (68.66 cm) at DI Khan during 2021, CPF-250 (68.00 cm) DI Khan 2020, CPF-252 (67.66 cm) at DI Khan 2021 and sugarcane variety (67.33 cm) at Charsadda 2020. While the minimum leaf length (57.33 cm) was recorded from sugarcane variety CPF-248 during 2021 at Charsadda.

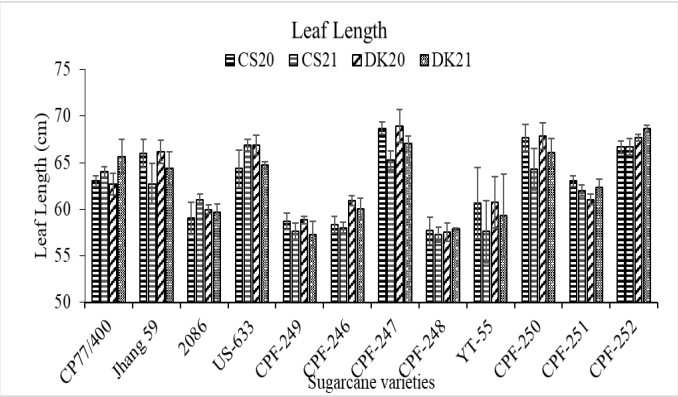

Figure 8: *Variation in leaf length of different sugarcane varieties at DI Khan and Charsadda during 2021-22.*

Variation in leaf width of different sugarcane varieties Charsadda and Dera Ismail (DI Khan) Khan during 2021-22

The variation in leaf width of different sugarcane varieties is presented in Figure 9. It can be assessed from the results that there is significant variation in width of sugarcane leaf of different varieties. Maximum leaf width (4.20 cm) was noted from CPF-252 at DI Khan during 2020 and 2021 that is eloquently greater than all other varieties grown at both locations which is followed by same variety (4.10 cm) during 2020 at Charsadda, CPF-250 (3.93 cm) in DI Khan during 2021 and CPF-252 (3.80 cm) in Charsadda. The minimum leaf width (2.70 cm) was recorded from sugarcane variety 2086 in DI Khan during 2020.

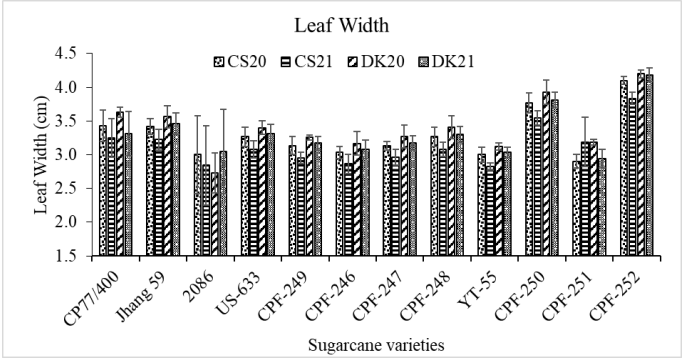

Figure 9: *Variation in leaf width of different sugarcane varieties at DI Khan and Charsadda during 2021-22.*

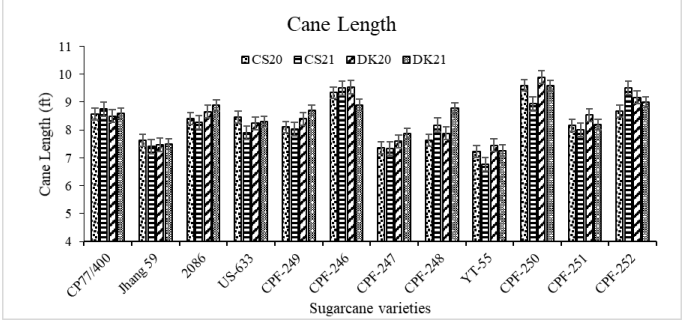

Figure 10: *Variation in Cane Length of different sugarcane varieties at DI Khan and Charsadda during 2021-22.*

Variation in cane length of different sugarcane varieties at Charsadda and DI Khan during 2021-22

The variation in cane length of different sugarcane varieties is presented in Figure 10. It can be elaborated from the results that there is significant variation in length of sugarcane cane of different varieties. Maximum mean length (9.90 ft) was recorded from sugarcane variety CPF-250 during 2020 in DI Khan followed by the same sugarcane variety with length (9.60 ft) during 2020 in Charsadda, CPF-246 (9.53 ft) during 2020 in DI Khan, CPF-246 (9.50 ft) during

2021 in Charsadda and CPF-250 (9.46 ft) during 2021 in DI Khan. While, the minimum cane length (6.90 ft) was recorded from YT-55 during 2021 in Charsadda.

Variation in cane diameter of different sugarcane varieties at DI Khan and Charsadda during 2021-22

The variation in cane diameter of different sugarcane varieties is presented in Figure 11. Significant variation was recorded in diameter of sugarcane cane of different varieties. Maximum diameter (3.20 cm) was observed from Jhang-59 at Charsadda during 202 that is at par with sugarcane variety 2086 (3.20 cm) at Charssada during 2021 but eloquently greater than all other varieties grown at Charsadda and DI Khan during 2020 and 2021. This was followed by Jhang-59 (3.13 cm) at Charsadda during 2020, CPF-247 (3.13 cm) at DI Khan during 2020, 2086 (3.10 cm) at Charsadda during 2020 and, YT-55 and CPF-250 (3.10 cm) at DI Khan during 2020. While the minimum diameter (2.20 cm) was recorded at CPF-246 during 2021.

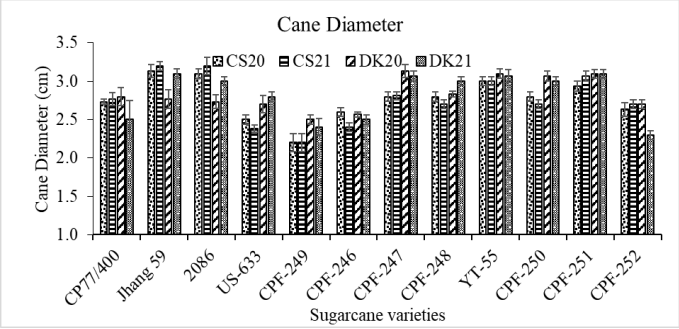

Figure 11: *Variation in Cane Diameter of different sugarcane varieties with at DI Khan and Charsadda during 2021-22.*

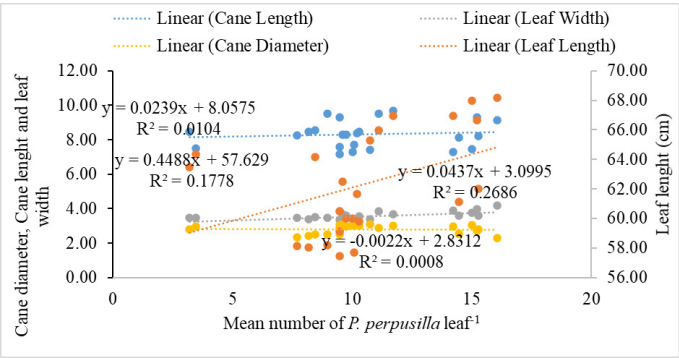

Figure 12: *Correlation between mean number of P. perpusilla leaf-1 and sugarcane morphological parameters.*

Correlation of P. perpusilla (eggs cluster and nymph/ adults leaf-1) with morphological characteristics of sugarcane

Correlation of mean *P. perpusilla* (eggs and nymph/ adults leaf^{-1}) with morphological characteristics (leaf length, leaf width, cane length and cane diameter) of sugarcane shown in Figure 12, 13. The correlation between *P. perpusilla* (eggs cluster and nymph/adults leaf^{-1}) and leaf length was recorded significantly positive with r^2= 0.57 and 0.42, respectively. Significantly positive correlation were also recorded between leaf width and *P. perpusilla* (eggs/ nymph and adults leaf^{-1}) with r^2= 0.68 and 0.5183, respectively. Moreover, the correlation between can length and *P. perpusilla* (eggs cluster and nymph/adults leaf^{-1}) was statistically non-significantly positive with r^2 = 0.42 and 0.10, respectively. The correlation between the cane diameter and *P. perpusilla* (eggs cluster and nymph/adults leaf^{-1}) were recorded negatively non-significant with r^2= -0.25 and 0.029, respectively.

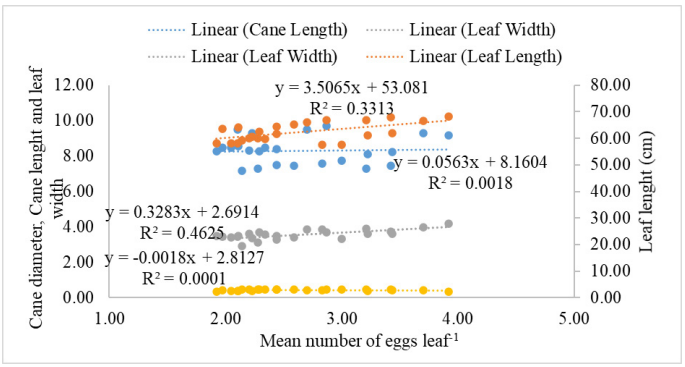

Figure 13: *Correlation between mean number of eggs leaf-1 and sugarcane morphological parameters.*

Sugarcane is a major cash crop for most of the farmer in Pakistan. Every year, the country's requirement for sugar production upsurges. Farmers have several challenges in achieving high output. Insect pests, in particular *Pyrilla perpusilla* is a key constraint in its production, which is primarily suppressed by various chemical pesticides; however, resistance to these insecticides has been observed in the last decades. One the safe alternative is the use such of varieties, which shows resistant against this ruinous pest.

For this purpose, experiments were conducted to test different sugarcane varieties i.e., CP77/400, Jhang 59, 2086, US-633, YT-55, CPF-252, CPF-246, CPF-251, CPF-247, CPF-250, CPF-248, and CPF-249 against *P. perpusilla* in district Charsadda and Dera Ismail Khan during the year 2020 and 2021 and also to correlate the mean number of *P. perpusilla* with biotic and biotic factors. The results of the experiment regarding the mean number of *P. perpusilla* (eggs/ nymphs and adults leaf^{-1}) revealed that both the number of egg clusters and nymph/ adults that were counted on each leaf were significantly different among all the tested sugarcane varieties that were evaluated

during the entirety of the study period (2020-2021). In both locations (Charsadda and Dera Ismail Khan), significant maximum mean number of (egg clusters and nymph/ adults) leaf^{-1} were recorded on sugarcane variety CPF-252 while the minimum mean number (egg clusters and nymph/ adults) leaf^{-1} were recorded on sugarcane variety CPF-249 during the studied years. These results are agreed with Prince (2020) who screened seven sugarcane varieties against *P. perpusilla* in district Rahimyar Khan from April-December, 2020 and concluded that sugarcane varieties (J69, UP286, CP70 and UP272 are less susceptible to *P. perpusilla* as compared to CPF-237, UP234 and UP235. The results of the present research results are also in line with Rasul *et al*. (2014) who evaluated different sugarcane varieties against *P. perpusilla* and reported significantly differences in mean number of *P. perpusilla* leaf^{-1} among the evaluated sugarcane varieties. Similarly, the results of this study are also at par with Chaudhary *et al*. (1999), Kishore *et al*. (2002), and Shrivastava *et al*. (2003), who examined different sugarcane varieties and specified the susceptible and resistant varieties against *P. perpusilla*.

Moreover, the results regarding the mean number of *P. perpusilla* (egg/nymphs and adults leaf^{-1}) during different months revealed significant difference during both years of the study at both locations. Initially, the mean number of *P. perpusilla* were recorded low (during March) which increased significantly to the peak till the month of August. Afterwards, mean number of *P. perpusilla* regularly decline in followed months till November. These findings are in line with Kumar *et al*. (2006) who studied the population dynamics of *P. perpusilla* and reported the peak activity of this pest in the August. The results are also at par with Rana *et al*. (2002) who recorded the population dynamics of *P. perpusilla* and reported that the first appearance of *P. perpusilla* in March, which reached to peak in August then gradually decline till the November. These findings are also in line with Ganehiarachchi and Fernendo (2008) who found the maximum population of *P. perpusilla* in July-August. The current results are also at par with Chaudhary *et al*. (2014) who also finds the highest population of *P. perpusilla* in the July and August which then decline in the September and followed months. According to Mishra (2005), the environmental conditions of July and August accelerate the multiplication of *P. perpusilla* in most of the sugarcane growing areas. Chaudhary and Sharma (1990) recorded the peak activity of *P. perpusilla* in the 2nd fortnight of August which started decrease till the last week of September. Similarly, Mahesh *et al*. (2019) studied population of *P. perpusilla* for three years and reported the peak abundance of this pest during August and September. The variations in the appearance and peak activity of *P. perpusilla* during different time of the year may due to differences in areas climatic conditions (Joshi *et al*., 2018). Ullah and Khalid (2007) reported the peak activity of *P. perpusilla* in November. Similarly, Hugar *et al*. (2002) found the peak of *P. perpusilla* in 2nd fortnight of September. During the experimental study in Haryana, the highest abundance of *P. perpusilla* were recorded in the July Chauhary *et al*. (1987). Correspondingly, Joshi *et al*. (2018) noticed the maximum activity of *P. perpusilla* in the last week of September and 1st week of October.

Furthermore, in the present results the correlation between mean numbers of *P. perpusilla* (eggs clusture/ nymphs and adults leaf^{-1}) and a biotic parameters (humidity, average temperature and rainfall) were stuied which results reveals that there was significantly positive correlation between mean numbers of *P. perpusilla* (eggs/nymphs and adults leaf^{-1}) and a biotic parameters (humidity and rainfall. These findings are in line with those of Chaudhary *et al*. (2014) who reported positive significant correlation between *P. perpusilla* population with relative humidity and average rainfall. In the present study, raise in average temperature also shows significant positive correlation with *P. perpusilla* (eggs and nymphs/adults) population leaf^{-1}. These results are also agreed with Choudhary *et al*. (2014) reported that raise in average temperature ranging from 24-32 ˚C accelerate the population build-up of *P. perpusilla*. The results regarding the average temperature are also at par with Rana *et al*. (2002) whose results revealed that raise in average temperature boasted *P. perpusilla* population. Similarly, these results of the current research are also in line with Joshi *et al*. (2018) who reported the significant positive correlation between *P. perpusilla* (eggs and nymphs/ adults) with temperature, humidity. There is also disagreed with Joshi *et al*. (2018) with their results regarding the negative effect of rainfall on the population *P. perpusilla* but results are agreed with the positive correlation of *P. perpusilla* (eggs) with rainfall. Mahesh *et al*. (2019) also reported significant positive correlation of *P. perpusilla* population with humidity.

Moreover, the correlation between *P. perpusilla* (eggs

clusters and nymph/adults leaf^{-1}) and leaf length was found significantly positive with r^2 = 0.57 and 0.42, respectively. Significantly positive correlation were also recorded between leaf width and *P. perpusilla* (eggs clusters/ nymph and adults leaf^{-1}) with r^2 = 0.68 and 0.5183, respectively. Similarly, the correlation between can length and *P. perpusilla* (eggs/ nymph and adults leaf^{-1}) was positively non-significantly with r^2 = 0.42 and 0.10 respectively. The correlation between the cane diameter and *P. perpusilla* (eggs/ nymph and adults leaf^{-1}) were recorded negatively non-significant with r^2= -0.25 and 0.029, respectively. The increasing population of *P. perpusilla* negatively influences different morphological properties of sugarcane crop. These results are in line with Rasul *et al*. (2014) who reported significantly positive correlation between sugarcane cane length and leaf width with *Pyrilla perpusilla* population and non-significant correlation between leaf length and cane diameter. Our studies are at par with Kumarasinghe *et al*. (2001) who stated that sugarcane leaf morphological characters effect the behaviour of *P. perpusilla* population build-up. Likewise, the current results are at par with those of Deepak *et al*. (1999), who reported that cane-length and cane-diameter showed a non-significant correlation with the leafhopper population in contrast to the current studies, which showed that cane-diameter showed a non-significant while cane-length showed a significant positive correlation with the pest-population. The current investigation is in line with those of Madan (2001), who reported that who found that *P. perpusilla* prefers varieties with broad leaves over those with minimum leaf width and with hard midribs.

Conclusions and Recommendations

Pyrilla perpusilla mostly attacked on CPF-252 due to its most preference by pest while CPF-249 variety showed least preference to *P. perpusilla* attack in both location and both years of the study (2020-2021). The peak activity of *P. perpusilla* (eggs clusture and nymphs/adults) was noted in the August at both locations. Significantly, positive correlation was recorded between *P. perpusilla* (eggs clusture and nymphs/adults) population infestation and average abiotic factors (temperature, humidity and rainfall). The correlation between leaf length and leaf width with *P. perpusilla* (eggs clusture and nymphs/adults) was significantly positive, the correlation of *P. perpusilla* (eggs clusture and nymphs/adults) with cane length was non-significant but positive while negative non-significant correlation was found between *P. perpusilla* (eggs clusture and nymphs/adults) population and cane diameter.

The uses of resistant sugarcane variety is effective method for the suppression of *P. perpusilla* population. It is recommended for the growers that Sugarcane variety CPF-249 shows comparatively less *P. perpusilla* population, which can be combine in future, IPM programmes for the clampdown of *P. perpusilla* infestation.

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Novelty Statement

Novelty of the study is to test different sugarcane varieties against *Pyrilla perpusilla* and the effect of biotic and a abiotic parameters on the population build-up of this pest for first time in two districts of Khyber Pakhtunkhwa.

Author's Contribution

Imtiaz Khan: Conducted the experiment and wrote the manuscript.
Bashir Ahmad: Designed and supervised the experiment.
Ahmad ur Rahman Saljoqi: Technically overviewed the manuscript.
Shah Alam Khan: Reviewed the manuscript.
Javed Khan: Supervised the field work.
Muhammad Azim Khan: Analyzed data.

Conflict of interest
The authors have declared no conflict of interest.

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