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WHITEFLY (*Aleurolobus barodensis* Mask.) SPATIO-TEMPORAL TRENDS IN SEMI-ARID AGRO-ECOLOGICAL ZONES OF PAKISTAN

Nasir Masood[1,2,*], Muhammad Ashfaq[1], Munawar Iqbal[3], Tanveer Hussain[5], Saeed Ahmad Qaisrani[4], Muhammad Kashif Bhutta[2,] Mueen Alam Khan[5] and Wajid Nasim[1]

[1]Department of Environmental Sciences, COMSATS Institute of Information Technology, Vehari-61100, Pakistan
[2]Department of Agricultural Entomology, Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan;
[3]Department of Chemistry & Bio- Chemistry, University of Agriculture, Faisalabad-38040, Pakistan;
[4]Department of Agronomy, Faculty of Agriculture, University of Agriculture, Faisalabad-38040, Pakistan;
[5]University college of Agriculture &Environmental Sciences, The Islamia University, Bahawalpur, Pakistan;
[*]Corresponding author's e.mail: nasirmasood2004@yahoo.com

Three farmer's fields of sugarcane of 10-15 Kilometer (Km) radius in environs of Layyah Sugar Mills, Layyah (LSL), Sheikhoo Sugar Mills, Muzaffargarh (SSM) and Indus Sugar Mills, Rajan Pur (ISR) were selected to evaluate the fluctuation in whitefly population. The data were recorded at fortnight interval during the crop season in 2008 and 2009 from April to December by randomly selected twenty leaves from each field of one hectare at each locality. The data were correlated with the ambient weather factors (temperature, humidity and rainfall). The population of whitefly (nymph and adult) varied significantly ($P \leq 0.05$) among observation interval and localities. The whitefly appeared during second fortnight of June in district LSL and ISR, while in district ISR it was appeared during first fortnight of July. The maximum mean population was recorded on first fortnight of November in district LSL (7.96/leaf) and ISR (14.94/leaf), while on second fortnight of October in district SSM (15.81/leaf). The ISR showed maximum whitefly population (4.61/leaf), while district LSL furnished lower population (2.48/leaf). It was found that the relative humidity had positive and significant ($P \leq 0.05$) correlation with the whitefly population and it contributed 42.3%, 43.8% and 35.9% in LSL, SSM and ISR district, respectively and the trend of whitefly appearance was found similar in 2008 and 2009. The relative humidity played positive and significant role for population fluctuation during the month of October and November.

Keywords: Agro-ecological zone, spatio-temporal region, sugarcane, weather conditions, whitefly

INTRODUCTION

Proper crop growth is a pre-requisite for increased yields and various natural factor such as pest infestation oppose the growth and development of crops (Thumar and Kapadia, 1995; Mishra and Singh, 2011; Rasual *et al.,* 2010). The researchers are trying to explore the techniques which must be proficient, eco-friendly, clean and affordable to reduce pest infestation on crops. Biological, chemical and mechanical treatments are being in practice for the reduction of pest infestation, which is better step to enhance the yield per hectare (Pandya, 2005; Iqbal *et al*., 2012; Khan *et al*., 2010; Nadeem *et al.,* 2010; Abbas *et al.,* 2012). Chemical concerts were found to be effective to control the pest infestation; however, it might be detrimental at lateral stages of development (Mehta *et al*., 2011; Chatha *et al.,* 2011; Ghaffar *et al.,* 2011). The metrological conditions such as rainfall and relative humidity also affect the pest fluctuations (Bahadar *et al*., 2002; Ansari and Lin, 2010; Kiran *et al*., 2011; Rameshi *et al*., 2011; Gogoi and Kumaria, 2011).

Among various sugarcane pests, the whitefly is considered one of the most dreaded pests responsible of sucking cell sap from leaves and some times it became an endemic to the sugarcane crop. The population of this specie flare-up very fastly and reaches up to economic threshold level (10 per leaves) enormously under water logged condition and nitrogen deficient areas (Ahmed *et al*., 2004; Mann *et al*. 2006; Ansari *et al.*, 2011). The adults of whitefly are small pale yellow about 3 mm long, ovate in outline with black and grey coating on the body. Only the nymphs are found on the underneath of the leaves and cause the damage by sucking the cell sap and it became pale and dry afterword. Ultimately, the leaves turn black in lieu of the development of fungus and render the crop unfit as fodder (Parsana *et al*., 1995; Mann and Singh, 2003; Ansari *et al*., 2007). The whitefly as economic pests seems to expanding continuously and insect damage crop by extracting large quantities of phloem sap which can reduce yield up to 50%. The honey dew excreted by this insect serves as a medium for sooty mold and fungi growth and few species of whitefly serves as vectors of several economically important viral plant pathogens (Byrne and Bellows, 1991).

On the other hand, the sugarcane (*Saccharum officinarum* L.) is an important cash crop of Pakistan and grown through out the tropical and subtropical parts of the world (Khaliq, 2002). Sugarcane plant during their different growth stages

are attacked by a number of insect which are major constraints in getting low yield (Aonnymous, 2006; Iqbal *et al*., 2012). Due to heavy infestation of the pests, serious decline (86.00% reduction in cane yield; 1.4-1.8% reduction in sugar recovery) has been reported (Anonymous, 2006). In Pakistan, the estimated area under sugarcane cultivation is 966 thousand hectares with an annual production of 47244 thousand metric tons with an average yield of 48.91 metric tons per hectare which is very low as compared to various other sugarcane growing countries such as Columbia (136.27), Egypt (121.00), Australia (85.00), USA (66.18), Indonesia (81.39), Brazil (72.85), India (61.95), South Africa (69.63) and Philippine (81.58) metric tons per hectare (Anonymous, 2006). Due to high reproduction as well as damage potential, sucking cell sap and acquired resistance to most commonly used insecticide, the control of whitefly has become increasingly difficult with insecticide. Moreover, the indiscriminate use of these insecticides since past few decades has led to many serious problems like resurgence of minor pests, destruction of beneficial fauna and environmental pollution. There is a need to explore alternative methods to reduce the use of pesticides and their adverse effects on environment and human health. For this purpose integrated control strategy for sustainable management of this pest is inevitable (Jena and Nayak, 1994; Thumar and Kapadia, 1994).

In view of sugarcane crop importance, little attention has been given for the improvement of this crop to pest infestation control. In this regard, the present research work was planned to study the whitefly population fluctuation in sugarcane at different ecological regions (ISR, SSM and LSL during 2008 and 2009).

MATERIAL AND METHODS

Experiments were conducted in three farmer's fields around sugar mills area (LSL, SSM, and ISR). The population was recorded in vicinity of sugar mills from 10-15 km radius for population count of whitefly (nymph and adult) throughout the crop season at fortnightly interval from April to December in 2008 and 2009 by randomly selected twenty leaves from each field of an area of one hectare from each locality. The metrological data during experimental area is shown in Table 1. The whitefly population was recorded and correlated with metrological data.

***Statistical analysis*:** The data were analyzed statistically following RCBD in three replicate and means were compared by DMR test (P=0.05) to find the significant difference among various localities. The data were also processed for simple correlation (r). The combined effect of the factors like temperature, relative humidity and rainfall on the population of whitefly was measured by using a multiple Linear Regression Equation (Table 4).

$Y = a+b2x_2+b2+2+b2x_2$…… where population of the insects was taken as the Response Variable (Y) and the following 'predictor' variables were used to represent the equation.

X_1= Maximum temperature for every 15 days,
X_2 = Minimum temperature for every 15 days
X_3 = Average mean temperature for every 15 days,
X_4= Average relative humidity for every 15 days and
X_5= Total rainfall (mm) for every 15 days.

RESULTS

Results show that the different spatio-temporal condition affected the whitefly population considerably. The population of whitefly was found significant at 95% confidence interval of mean at different dates of observation, locality. The population fluctuation of whiteflies is given in (Table 2). It is evident from the results that population of whitefly appeared on second fortnight of June in district LSL and SSM and on first fortnight of July in district ISR (Table 3 and 4). The whitefly density in 2008 and 2009 were found non- significant at 95% confidence interval of mean (Table 3 & 4). In district LSL, an increasing trend was observed from second fortnight of June to first fortnight of November and the population reached to its peak level of 7.96 /leaf whitefly (nymph + adult). The increasing trend in population density count in district SSM was started from second fortnight of June to second fortnight of October and reached to its peak level with 15.81/leaf whitefly (nymph + adult). Similarly, in District ISR, the population started from second fortnight of July and reached to its peak level on first fortnight of November, i.e. 16.94/leaf whitefly (nymph + adult). In general, the decreasing trend was observed thereafter on the subsequent observation in each district in comparison of their respective higher population. In first fortnight of December, the population level was found to be 3.09, 2.43 and 2.08/leaf whitefly (nymph + adult) in districts LSL, SSM and ISR, respectively and after that there was no significant variation. On an average basis, ISR District showed maximum population i.e. 4.61/leaf (nymph + adult) and this difference was also found significant versus districts LSL, SSM and LSL District showed minimum population of 2.48/leaf whitefly (nymph + adult) also showed significant difference with the population trend of other districts irrespective SSM to lowest population. The population of whitefly was recorded to be 3.89/leaf in district SSM which showed transitional trend as compared to other districts.

The multiple linear regression analysis along with coefficients of determination (R^2) between population of whitefly and weather factors (temperature, rainfall and humidity) at different localities is given (Table 5). The results showed that during second fortnight of October, temperature, rainfall and humidity showed strong relation with the population of whitefly in three localities. The

Table 1. Correlation coefficient values (r) between population of whitefly and weather factors at various localities of sugarcane growing areas of the Punjab, Pakistan during 2008

Weather Factors	Localities			Average
	Layyah	Muzaffargarh	Rajan Pur	
Max. Temp. (°C)	-0.364	-0.195	-0.231	-0.226
Min. Temp. (°C)	-0.447	-0.220	-0.202	-0.219
Av. Temp. (°C)	-0.422	-0.226	-0.227	-0.244
Relative Humidity (%)	0.440	0.270	0.211	0.303 *
Rainfall (mm)	-0.465	-0.231	-0.151	-0.279

*Significant at $P<0.05$

Table 2. Analysis of variance of the data regarding whitefly population in different district of the Punjab at various farmers' fields during 2008

Source of Variance	D.F.	F. Value	Probability
Replications	2	11.42 **	0.00
Dates of observation	15	107.80 **	0.00
Districts	2	34.41 **	0.00
Dates X Districts	30	6.55 **	0.00
Error	94		

CV = 34.93%; ** = Sgnificant at $P<0.01$

Table 3. Means comparison of the data regarding whitefly population in different districts of the Punjab, Pakistan at various farmer's fields during 2008

Dates of observation	Months	Interaction (LSD=2.07, SE=0.73)			Means LSD=1.19 SE=0.42
		Layyah	Muzaffargarh	Rajan Pur	
2nd fortnight	April	0.00 o	0.00 o	0.00 o	0.00 f
1st fortnight	May	0.00 o	0.00 o	0.00 o	0.00 f
2nd fortnight	May	0.00 o	0.00 o	0.00 o	0.00 f
1st fortnight	June	0.00 o	0.00 o	0.00 o	0.00 f
2nd fortnight	June	0.08 o	0.06 o	0.00 o	0.05 f
1st fortnight	July	0.10 o	0.62 o	0.20 o	0.31 f
2nd fortnight	July	0.16 o	0.84 mno	0.12 o	0.37 f
1st fortnight	August	0.73 no	0.61 o	2.12 lmno	1.15 f
2nd fortnight	August	2.33 klmno	1.99 lmno	4.28 hijkl	2.87 e
1st fortnight	September	3.21 ijklm	4.70 ghijk	5.72 fgh	4.54 d
2nd fortnight	September	4.67 ghijk	7.95 ef	9.19 e	7.27 c
1st fortnight	October	5.59 ghi	12.53 cd	12.28 d	10.13 b
2nd fortnight	October	6.87 fg	15.81 ab	14.52 bc	12.40 a
1st fortnight	November	7.96 ef	9.54 e	16.94 a	11.48 a
2nd fortnight	November	4.88 ghij	5.10 ghij	6.24 fgh	5.40 d
1st fortnight	December	3.09 jklmn	2.43 klmno	2.08 lmno	2.53 e
Means (LSD= 0.51, SE=0.18)		2.48 c	3.89 b	4.61 a	

The similar letters in columns are presenting significantly different by DMR Test at P = 0.05.

Table 4. Means comparison of the data regarding whitefly population in different districts of the Punjab, Pakistan at various farmer's fields during 2009

Dates of Observation	Months	Interaction (LSD=2.07, SE=0.73)			Means LSD=1.18 SE=0.43
		Layyah	Muzaffargarh	Rajan Pur	
2nd fortnight	April	0.00 o	0.00 o	0.00 o	0.00 f
1st fortnight	May	0.00 o	0.00 o	0.00 o	0.00 f
2nd fortnight	May	0.00 o	0.00 o	0.00 o	0.00 f
1st fortnight	June	0.00 o	0.00 o	0.00 o	0.00 f
2nd fortnight	June	0.08 o	0.06 o	0.00 o	0.05 f
1st fortnight	July	0.11 o	0.62 o	0.20 o	0.31 f
2nd fortnight	July	0.15 o	0.85 mno	0.11 o	0.38 f
1st fortnight	August	0.72 no	0.62 o	2.11 lmno	1.16 f
2nd fortnight	August	2.32 klmno	2.00 lmno	4.26 hijkl	2.89 e
1st fortnight	September	3.19 ijklm	4.72 ghijk	5.69 fgh	4.56 d
2nd fortnight	September	4.66 ghijk	7.96 ef	9.20 e	7.26 c
1st fortnight	October	5.57 ghi	12.55 cd	12.26 d	10.15 b
2nd fortnight	October	6.86 fg	15.82 ab	14.51 bc	12.41 a
1st fortnight	November	7.98 ef	9.52 e	16.96 a	11.46 a
2nd fortnight	November	4.89 ghij	5.09 ghij	6.26 fgh	5.38 d
1st fortnight	December	3.10 jklmn	2.41 klmno	2.11 lmno	2.51 e
Means (LSD= 0.52, SE=0.17)		2.48 c	3.90 b	4.6 a	

The similar letters in columns are presenting significantly different by DMR Test at P = 0.05.

Table 5. Multiple linear regression analysis along with coefficients of determination (R^2) between population of whitefly and weather factors at different localities

	Regression Equation	R^2	Role (%)
	Layyah		
Y =	4.478 – 0.6213 x1	0.133	13.3
Y =	9.0723 – 0.08483 x1 – 1.009 x2	0.201	6.8
Y =	9.4567 – 11.529 x1 – 15.649 x2 + 25.978 x3	0.219	1.8
Y =	- 24.4645 + 8.885 x1 + 20.345 x2 – 27.870 x3 + 1.689 x4	0.642	42.3
Y =	- 22.328 + 9.827 x1 + 20.484 x2–29.048 x3+1.5711 x4 – 0.0581 x5	0.658	1.6
	Muzaffargarh		
Y =	3.132 – 0.2909 x1	0.038	3.8
Y =	5.3584 – 0.1151 x1 – 0.4999 x2	0.051	1.3
Y =	11.5766 + 11.852 x1 + 14.612 x2 -28.347 x3	0.126	7.5
Y =	- 31.1338 – 10.722 x1 – 9.131 x2 + 19.600 x3 + 3.7246 x4	0.564	35.9
Y =	- 40.0518 – 16.571 x1 – 16.106 x2 + 33.015 x3 + 4.437 x4 – 0.2007 x5	0.715	15.1
	Rajan Pur		
Y =	3.3570 – 0.298 x1	0.053	5.3
Y =	4.4613 – 0.2223 x1 – 0.2412 x2	0.059	0.6
Y =	4.6309 – 0.1906 x1 – 0.1098 x2 – 0.2045 x3	0.059	0.00
Y =	- 6.4614 – 0.1911 x1 + 0.764 x2 – 3.1016 x3 + 2.5604 x4	0.418	43.8
Y =	- 10.29299 – 0.3182 x1 + 0.2142 x2 – 2.9148 x3 + 3.4166 x4 – 0.2606 x5	0.609	19.1
	Cumulative		
Y =	3.2624 – 0.3205 x1	0.051	5.1
Y =	4.7742 – 0.2038 x1 – 0.3416 x2	0.059	0.8
Y =	4.916 – 0.1068 x1 – 0.1176 x2 – 0.3601 x3	0.061	0.2
Y =	0.5581 – 0.2097 x1 + 0.1991 x2 – 0.8883 x3 + 0.7058 x4	0.244	18.3
Y =	0.9128- 0.2558 x1– 0.2386 x2 – 0.320 x3 + 0.6605 x4 – 0.0905 x5	0.279	3.5

X1= Maximum temperature °C; X2 =Minimum temperature °C; X3 = Average temperature °C;
X4 = Relative humidity (%); X5 = Rainfall (mm)

district SSM showed the R^2 value of 43.8 followed LSL and ISR with R^2 value of 42.3 and 35.7. The cumulative effect of all localities was also found higher at second fortnight of October. In general, the significant decreasing trend was observed there after on the subsequent observation and reached to a level on second fortnight of November. From these results, it was found that the period from last week of September to third week of October was the most favorable period for the production of whitefly.

DISCUSSION

The data on whitefly population and its comparison with spatio-temporal weather condition showed a significant difference. It was evident from the results that in district LSL and SSM, the population of whitefly was appeared during the second fortnight of June, while in district ISR it appeared during the first fortnight of July. An increasing trend was observed thereafter in all the districts and reached to maximum of 7.96 and 16.94 individuals per leaf during first fortnight of November in districts LSL and ISR, respectively. Furthermore, it was observed that the population was fluctuated towards maximum trend from first fortnight of September to second fortnight of November. However, first fortnight of November showed the maximum peak in district LSL and ISR, whereas in district SSM the second fortnight of October was found to be very crucial period for the development of the pest. Keeping in view, the relationship of weather factor (temperature, rainfall and humidity) on population fluctuation of the whitefly, it was observed that the relative humidity played a significant and positive role and contributed 42.3%, 43.8%, 35.9% and 18.3% in population fluctuation on the population of whitefly in the spatio-temporal conditions of LSL, SSM and ISR on cumulative basis, respectively.

It is well known that the weather conditions are considered to be the forecast of pest fluctuation. The pest requires a critical condition for their fluctuation, because the critical weather condition affects the life cycle phases of pest. A study on the occurrence and the abundance of whitefly reveal that infestation commenced from mid July (1.50 nymphs/ cm^2 per leaf) and reached to a peak (3.93 nymphs cm^2 per leaf) in the first week of October and these results are in line with Thumar and Kapadia (1995) who reported that the nymph population was highest in the period between mid September to November (3.13 to 3.95 nymphs per cm^2. The average nymphal and pupal population in a year ranged from 0.95-17.05 and 0.63-13.25, respectively. The peak activity was observed during July to December for nymphs and June to November for pupae and our finding were also found comparable with Pandya (2005) that the average population of nymph and pupae of sugarcane whitefly ranged from 0.95 to 17.05 and 0.63 to 13.25 cm^2 per leaves, respectively during different months of the year. The peak activity of nymph was observed during July to December, while that of pupae during June to November.

***Conclusion*:** The population was appeared during second fortnight of June in district LSL and SSM, while in district ISR appeared during first fortnight of July. The trend was found to be similar in 2008 and 2009, which might be due the similar weather condition, because the humidity was found positively correlation with whitefly population. The peak population was recorded on first fortnight of November to second fortnight of October in three districts. On an average basis, the district ISR showed maximum population, while district LSL furnished the lowest density. It is suggested that the sugarcane growers should be attentive during month of October and November.

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