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Studies on the Seasonal Incidence of the Whitefly (*Dialeuropora decempuncta* Quaintance and Baker) Causing Leaf Curl on Mulberry in Relation to Abiotic Factors

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A study was conducted to examine the relationship between abiotic factors and the population of whitefly (*Dialeuropora decempuncta*) in mulberry field. The study reveals that relationship between abiotic factors and the whitefly population is very much existent like other pests in other agricultural crops. Duration and time of distinct occurrence of whitefly in mulberry is influenced by the abiotic conditions of field. Abiotic parameters of previous month are more important in influencing the intensity of the pest than the current abiotic factors. Not all the abiotic factors are equally important but factors like minimum temperature, fluctuation in temperature during the day, minimum relative humidity, fluctuation in relative humidity and rainfall are the major important factors in influencing the intensity of the pest under consideration.

Key words : Whitefly, Mulberry, Abiotic factors, Population.

Introduction

Mulberry, *Morus alba* is the sole food plant of silkworm, *Bombyx mori*. India is the second largest silk growing country, producing about 11,487 tones of raw silk, covering 3,420,000 ha under mulberry cultivation, out of which 50,198 ha are in West Bengal. Like most of the other economic plantation and field crops, mulberry is prone to the attack of a varied pest complex belonging to a large number of insect orders. Though the frequent leaf plucking and pruning of the shoot restrict the attack of pest, many of them still find enough time and pace on mulberry for feeding and breeding.

Whitefly, a phytophagous insect show varying degrees of association with particular plant species or a group of plants on which they feed. The change in the threshold of feeding stimuli plays a crucial role in host selection by insects.

Several species of whitefly have been recognized as pest of different agricultural crops, vegetables, fruits all over the world (Hussain and Trehan, 1933; Pruthi and Samuel, 1942; Vasudeva and SamRaj, 1948; Ohnesorge, *et al.*, 1980). Along with other major mulberry pests like mealybug *Maconellicoccus hirsutus* and thrips *Pseudodendrothrips mori,* one more hazardous pest, whitefly, *Dialeuropora decempuncta* (Quaintance and Baker) started infesting the mulberry garden and has become a major problem today (Bandyopadhyay *et al.,* 1997). It reduces nutritional values of mulberry leaf and also results in 23.45% mulberry leaf yield loss.

It also acts as a potential vector of leaf curl virus. The incidence of leaf curl virus was found to be directly related to the population dencity of white fly vector (Sastry and Singh, 1974; Anzola and Lastra, 1985).

Environments in nature rarely, if ever, remain constantly favourable or unfavourable but fluctuate irregularly between two extremes. The animals innate capacity for increase fluctuates correspondingly, being sometimes positive and sometimes negative. While conditions remain favourable and the innate capacity for increase remains positive, the numbers increase. If it remained so indefinitely, the species would continue to multiply (Andrewartha and Birch, 1954).

Population dynamics in insects are the result of interaction between physical condition, population movements and both density dependent and independent factors. The relative importance of each of the factors might vary

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among populations or even within a population from time to time (Huffaker *et al.*, 1984). Dynamics of the population of whitefly *Bemisia tabaci* is governed by a number of abiotic factors which exert an influence over the population of whitefly (Verma *et al.*, 1989).

Advance information on the impending situation of pest population is useful for remaining in preparedness to face the exigencies. In priciple it should be of foremost importent in insect pest management programme. Keeping in view of the importance of whitefly as a serious pest and vector of viral diseases, an effort was made to study i) population size of whitefly on mulberry in relation to weather factors, ii) to recommend/ suggest field machineries to take necessary preventive measures in protecting the mulberry crop before the severe onset of pest infestation, iii) to formulate a forewarning calender which will be helpful.

Materials and Methods

The population size of whitefly was studied in the mulberry fields of Central Sericultural Research and Training Institute, Berhampore during the year April 1995 to March 1997. Population of whitefly was recorded at weekly intervals in randomly selected 11 mulberry plots. The horizontal population of whitefly was assessed by taking adult population from top two leaves because in general, adults are most abundant on tender leaves, where as the vertical population was assessed by consideration top (1-3), middle (4-7) and bottom (7-14) strata. Similar technique was employed by Lynch and Simmons (1993) in peanut, Purohit and Deshpande (1991) in cotton. In each plots 3 plants were selecetd randomly and in each plant top, middle and bottom portions were selected for counting adults, early nymphs and late nymphs respectively.

The investigations were made during cooler hours of the day preferably 6 A.M. to 7 A.M. as per the methodology suggested by Avidov (1956), Butler (1983), and Naranjo and Flint (1995). Counts were made carefully turning the leaf over by rotating the petiole or the tip of the leaf blade (Naik and Lingappa, 1992; Narango and Flint, 1995). To reduce disturbance that might have interfered with an accurable census, counts were done on two leaves (top, middle, bottom) on each 3 consecutive plants at a sample site. The mean of plant densities was 11,000/Acre.

As because there is a difference in the behaviour of abiotic factors namely maximum and minimum temperature, relative humidity and rainfall in between the two years of experimentation, the possibility of pooling the data for two years together may not be a wise proposition. The variability in population of whitefly at different levels namely horizontal and vertical (Top, middle and bottom) also varies during the same month of two consecutive years of the study. Hence yearwise study of relationship between pest population and abiotic factors was adhered to. Multiple Regression Analysis following the method of Ordinary Least Square (OLS) technique (Draper and Smith, 1981) is applied to judge the relationship between population and abiotic factors; fittings of the regression equations were adjudged by the significance test of R^2 (the coefficient of determination).

Results and Discussion

At any point of time, population of whitefly at different plant canopy level (Viz. horizontal, top, mid and base level) of mulberry is found to be different (Fig. 1). Though the maximum population is noticed at the base level, population at top level is also not much different from it. Depending upon the abiotic conditions, time of incidence of whitefly also differ from year to year. During the year 1995 the time of distinct incidence of whitefly was from August to December, whereas the same for the year 1996 was from June-July to November.

The whitefly incidence started raising from June (5.33 adults/leaf) with mean temperature 32.87°C, increase in average relative humidity 83.87% and rainfall 190.00 mm (Table 1) in the years 1995 to 1996 but it shows more in the month of June for the year 1996 to 1997 i.e. 13.73 adults/leaf with avg. temperature 29.38°C, avg. relative humidity 81.83% and rainfall 178.70 mm (Table 1).

The population reached its peak during September i.e. 30.38 adults/leaf with average temperature 29.40°C, average R.H. 86% and rainfall 322.30 mm. in the year 1995 to 1996 but to population boosted up 55.46 adults/leaf in the year 1996-1997 with average temperature 29.43°C, R.H. 81.71% and rainfall 129.30 mm. Similar observations were found in cotton (Jackson 1973) and tobacco (Reddy *et al*, 1996).

Further the decline in pest population started from October and remained negligeable (0.01-1.91 adults/leaf) during January to May (Table 1). Correlation analysis revealed that not all the abiotic factors viz. maximum temperature, minimum temperature, maximum and minimum relative humidity and rainfall are equally important in governing the pest population at different plant canopy level. Among the factors minimum relative humidity is found to have positive significant influence on the population of pest (Table 2) which means higher the minimum relative humidity in atmosphere higher will be the pest population. Though rainfall is found to be associated positively with pest population, it fails to influence the pest population significantly. Due to rainfall the pH value

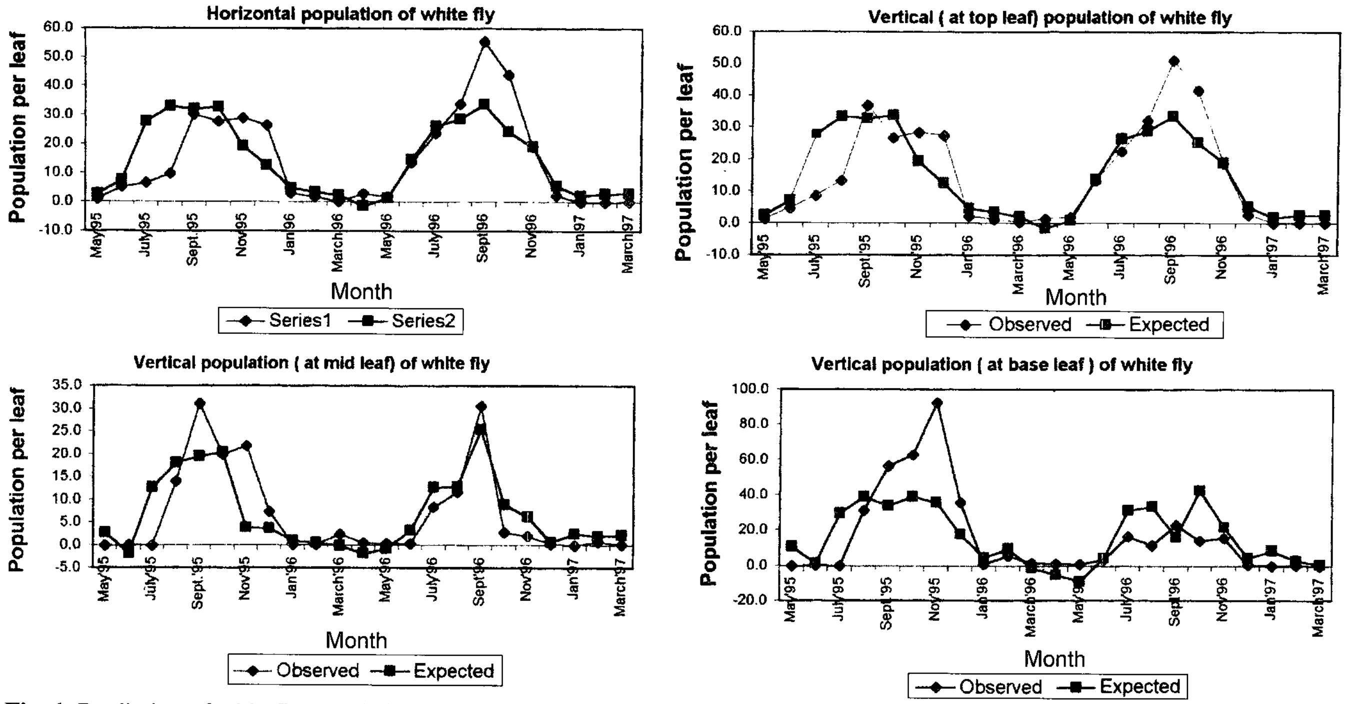

Fig. 1. Prediction of whitefly population based on ablotic factors.

of the cell sap of leaves become high. The reason for higher infestation can be partially attributed to high pH value of the cell sap of the leaves (Husain and Trehan, 1933).

The general incidence of whitefly which persists from July through December is due to the presence of suitable temperature which was ranging 20°C-29°C. This temperature is quite ideal for hatching of whitefly eggs. Most interesting associationship is reaveled when the difference in maximum and minimum of both temperature and relative humidity are correlated with the pest population. In both the cases it was noticed that higher fluctuation in temperature and humidity are detrimental for incidence of whitefly population. That means a steady temperature and relative humidity (at higher level) are preferable for the incidence of whitefly population. Gameel (1978) reported 92-98% hatching at 25°C-35°C in *B. tabaci.* The adult emergence requires more temperature than that of egg hatching in *B. tabaci* (Verma *et al,* 1990).

Another interesting result was obtained when pest population at different plant canopy levels associated with abiotic factors of previous months. The finding of this study (Table 2) reflects greater intensity of linear associationship of one month lag abiotic factors with pest population. This clearly indicates that whitefly population depends more on abiotic factors of previous months, than of current month.

A thorough study of the lag correlation table (Table 2) revealed that among the abiotic factors minimum temperature, difference in temperature, minimum relative humidity, difference in relative humidity and rainfall are found to have most significant associationship.

An exercise to predict whitefly population at different plant canopy level having known the abiotic factors for the previous months with the help of Least Square Technique is undertaken. A comparative study of the prediction models fitted with all the lag abiotic factors and without the lag maximum temperature and relative humidity revealed that both the models are fitted equally well (Table 3). Five variable models do not show any prominent reduction in the value of R^2 and even show better significance level over the seven variable lag models. Thereby clearly pointing out the lesser importance of maximum temperature and maximum relative humidity in influencing the incidence of pest population.

Distribution of adults in the top three leaves suggest that these leaves are more succulent in nature and suitable for oviposition. Similar observations were made in *B. tabaci* (Rathi, 1972; Ohnesorge *et al.,* 1980; Ohnesorge and Rapp, 1986; Naik and Lingappa, 1992).

Van Arx *et al.* (1984) noted that the position of the cotton leaf mostly infested with *B. tabaci* nymphs varies with stage of plant development. Due to this higher number of late nymphal instars were observed in the lower canopy than early nymphal instar in the mid canopy. Similarly in the present study, it was found that the whitefly oviposit on the tender leaves. On hatching the nymphs remain on the same leaf due to sedentary habit. As host plant grows, the leaves with nymphal instars becomes lower in position. Due to this reason the highest nymphal population is

Table 1. Incidence of whitefly in relation to abiotic factors

Months	Population/Leaf				Abiotic factors				
	Y1	Y2	Y3	Y4	X1	X2	X3	X4	X5
April95	1.22 (0.14)	1.14 (0.47)	0.03 (0.03)	0.00 (0.00)	39.28	23.15	78.00	38.50	28.40
May95	1.13 (0.12)	1.23 (0.22)	0.00 (0.00)	0.00 (0.00)	39.02	26.76	93.75	40.25	39.00
June95	5.33 (0.53)	4.70 (1.19)	0.06 (0.03)	0.09 (0.00)	39.27	26.30	98.25	69.50	190.00
July95	6.76 (0.84)	3.88 (2.23)	0.00 (0.00)	0.00 (0.00)	33.21	25.77	98.00	77.25	250.00
Aug95	9.95 (1.39)	13.43 (3.09)	14.07 (5.36)	31.52 (7.31)	33.24	25.98	95.50	74.50	309.00
Sep95	30.38 (2.39)	36.96 (4.22)	31.18 (6.65)	56.51 (10.04)	32.83	24.45	97.00	75.00	322.30
Oct95	30.21 (2.22)	26.84 (3.49)	19.90 (7.12)	62.81 (16.90)	33.50	25.98	89.00	64.00	9.80
Nov95	28.97 (2.74)	28.40 (4.74)	21.88 (7.05)	92.92 (24.24)	30.10	18.45	97.00	59.00	33.40
Dec95	26.57 (2.66)	27.81 (4.31)	7.40 (2.02)	35.83 (10.76)	26.98	13.00	70.00	38.00	2.60
Jan96	3.08 (0.42)	2.33 (0.60)	0.15 (0.11)	0.83 (0.72)	27.50	12.02	80.00	56.75	0.00
Feb96	1.86 (0.45)	1.23 (0.73)	0.21 (0.20)	5.40 (2.65)	28.96	14.04	91.44	48.89	0.00
Mar96	0.28 (0.07)	0.31 (0.20)	2.42 (2.13)	1.45 (0.53)	35.16	19.38	82.58	42.61	8.00
April96	2.96 (0.75)	1.43 (0.38)	0.56 (0.39)	1.18 (0.44)	37.43	22.55	83.10	43.63	55.40
May96	1.91 (0.12)	2.00 (0.21)	0.36 (0.16)	0.92 (0,23)	37.63	25.47	88.64	58.67	72.90
June96	13.73 (1.02)	13.36 (1.85)	0.36 (0.27)	3.47 (0.98)	33.70	25.06	91.58	72.10	178.70
July96	23.91 (2.77)	22.62 (3.81)	8.50 (2.57)	16.56 (4.61)	34.00	26.20	93.19	74.77	182.40
Aug96	33.82 (2.97)	32.86 (4.98)	11.71 (2.79)	11.59 (3.06)	33.20	22.63	93.51	78.19	389.30
Sep96	55.46 (3.48)	51.12 (5.92)	30.67 (8.46)	22.95 (3.66)	32.78	26.08	92.60	70.83	129.30
Oct96	44.03 (2.56)	41.68 (4.38)	2.80 (1.23)	14.08 (2.71)	32.93	22.54	91.74	65.83	71.30
Nov96	19.18 (1.46)	18.75 (2.58)	2.04 (1.00)	15.61 (4.93)	31.13	16.98	89.13	51.86	0.00
Dec96	2.46 (0.46)	2.69 (0.84)	0.34 (0.30)	2.56 (1.27)	27.37	11.91	86.96	49.67	0.00
Jan97	0.10 (0.02)	0.13 (0.04)	0.00 (0.00)	0.04 (0.01)	25.19	9.93	93.06	51.03	0.00
Feb97	0.11 (0.02)	0.12 (0.04)	0.73 (0.71)	0.07 (0.04)	27.83	12.23	90.10	50.25	10.60
Mar97	0.20 (0.06)	0.11 (0.06)	0.14 (0.13)	0.00 (0.00)	34.40	18.70	85.74	43.00	0.00

Data within the parentheses indicates S.E

Notation:-Y1 = Horizontal Population
Y2 = Vertical Population on top region
Y3 = Vertical Population on middle region
Y4 = Vertical Population on bottom region

X1 = Avg. Maximum Temperature ×C
X2 = Avg. Minimum Temperature ×C
X3 = Avg. Maximum Relative Humidity %
X4 = Avg. Minimum Relative Humidity %
X5 = Total Rainfall (mm)

noticed on the lower canopy as compared to mid canopy.

Among the various factors of population buildup, the intrinsic capacity of reproduction of insect species play a vital role. From the duration of the damaging stage of insect, the level of damage can be realized and the duration of generation would indicate the possibility of recurrence of the pest during the crop schedule. However, all the life activities of the insects are also influenced by the weather factors as well as by the availibility of preferred host plant by the insect. It has also been established that the emergence of the adults of the insect in a large scale is related to the time of onset of monsoon.

From the present study it has become evident that if the rainfall and higher minimum relative humidity of the previous month ranges 120-322 mm and 69.5-78.19% respectively, it will enhance whitefly population of the following month above the economic threshold level (20 whitefly/plant). The findings of the present study have revealed that the whitefly population raises beyond economic threshold level during July-November (Table 1). In a calender year there are five commercial silkworm crops with fixed schedules at farmers level. These two commercial silkworm crops (Ashadh and Agrahayani) will be reared during high whitefly infestation period. To avert major yield loss due to the pest, after 3rd commercial crop (i.e. Ashadhi) (during 2nd week of July) farmers have to adopt ground pruning of mulberry and recommended dose of pesticide has to be sprayed during the first week of August, when the plantation attains an age of 20 days. Now the leaf which is free of whitefly population can be

Table 2. Correlation based on whitefly population and abiotic factors

Variables	Lag Correlation										
	Y1	Y2	Y3	Y4	X1	X2	X3	X4	X5	X6	X7
Horizontal Population (Y1)		0.992**	0.744**	O.565**	0.175	0.543**	-0.731**	0.382	0.772**	-0.720**	0.700**
Top Population (Y2)	0.992**		0.784**	0.608**	0.180	0.570**	-0.772**	0.401	0.810**	-0.756**	0.733**
Mid Population (Y3)	0.749**	0.789**		0.786**	0.093	0.419*	-0.616**	0.342	0.732**	-0.694**	0.776**
Base Population (Y4)	0.575**	0.618**	0.790**		0.062	0.395	-0.613**	0.263	0.589**	-0.565**	0.423*
Maximum Temperature (X1)	- 0.061	- 0.066	- 0.031	- 0.142		0.829**	- 0.207	- 0.587**	0.107	- 0.445*	0.253
Minimum Temperature (X2)	0.301	0.318	0.325	0.120	0.815**		- 0.719**	- 0.117	0.614**	- 0.800**	0.605**
Diff. In Temperature (X3)	- 0.585**	- 0.621**	- 0.591**	- 0.375	- 0.177	- 0.714**		- 0.524*	- 0.941**	0.846**	- 0.744**
Maximum Rh (X4)	0.396	0.420*	0.320	0.290	- 0.592**	- 0.105	- 0.539**		0.564**	- 0.137	0.370
Minimum Rh (X5)	0.556**	0.597**	0.515**	0.326	0.076	0.609**	- 0.944**	0.577**		- 0.895**	0.860**
Diff. In Rh (X6)	- 0.462	- 0.499*	- 0.453*	- 0.241	- 0.403	- 0.790**	0.856**	- 0.170	- 0.903**		- 0.833**
Rainfall (mm) (X7)	0.342	0.398	0.401	0.125	0.232	0.608**	- 0.752**	0.386	0.862**	- 0.836**	
	Correlation (Current)										

Note : * : Significant at p = 0.05 and ** : Significant at p = 0.01

Table 3. Lag models for Whitefly population at different plant canopy level with abiotic factors

Model parameters	Horizontal Population		Top Population		Mid Population		Base Population	
	1	2	1	2	1	2	1	2
Intercept constant	- 55.497	- 55.497	- 35.881	- 35.881	9.958	9.958	306.467	306.467
Maximum Temperature (X1)	-	- 2.491	-	- 2.455	-	-1.177	-	- 2.59
Minimum Temperature (X2)	0.372	2.863	0.246	2.701	- 0.403	0.774	- 2.198	0.4
Diff. In Temperature (X3)	0.315	2.806	- 0.19	2.265	0.142	1.319	- 7.871	- 5.28
Maximum Rh (X4)	-	- 1.415	-	- 1.166	-	- 0.44	-	- 0.66
Minimum Rh (X5)	0.912	2.327	0.761	1.927	0.131	0.572	- 1.514	- 0.85
Diff. In Rh (X6)	0.081	1.497	0.002	1.168	- 0.304	0.136	- 2.006	- 1.34
Rainfall (mm) (X7)	0.013	0.013	0.016	0.016	0.045	0.045	- 0.021	- 0.021
R	0.779	0.779	0.817	0.817	0.799	0.799	0.658	0.658
R^2	0.606	0.606	0.668	0.668	0.639	0.639	0.433	0.433
Significant at probability	0.004	0.02	0.001	0.008	0.002	0.014	0.06	0.2

Note : 1 refers to equation with 5 significant abiotic factors and 2 refers to equation with all the abiotic factors.

provided to the silkworms during 4th commercial crops, (i.e. Bhaduri) which starts on 20th August.

After completion of 4th commercial crop i.e. during 2nd week of September ground pruning of mulberry (Host Plant) has to be implemented and two sprays of recommended insecticide has to be followed at 15 days interval prior to 20th October of each year to facilitate qualitative leaf supply for the "Agrahayani" commercial crop (starting on 2nd November) which is the largest crop in the year. From this information it became possible to predict the time of invasion of this insect on the crop and severity of infestation. This forewarning is of immense value to agriculture as the farmers may remain alert about impeding disastrous consequences and take essential preventive and control measures to regulate the pest population below economic threshold level.

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