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Influence of meteorological factors on the build-up of whitefly (*Bemisia tabaci*) vector population and and incidence of chilli leaf curl virus disease in the plains of West Bengal

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Studies were undertaken for two consecutive years 2000 & 2001 on prevalance of whitefly (*Bemisia tabaci* Genn), vector of chilli leaf curl virus in relation to weather conditions. Counts of fortnightly average of whitefly population was made by direct counting from the chilli plant and by trapping through yellow stickly trap. Fortnightly average of maximum and minimum temperature, maxmimum and minimum ralative humidity and railfall were recorded. Whitefly population was observed throughout the year but their number varied in different months. After its appearance on January the population increased rapidly and reaching the peak during sceond fortnight of March and thereafter declined gradually reaching very low population during second fortnight of July and again slightly increased on first fornight of August. Positive significant correlation was found between vactor population with maximum and minimum temperature. Significant negative correlation was noted with maximum reletive humidity, minimum relative humidity and rainfall. Multiple regression showed that these factors are mainly responsible for the build-up of vector population. These meterological factors contributed to the extent of 84% to 90.5% and 72.30% to 92.30% for the buildi-up of whitefly population from direct count and yellow sticky trap respectively.

Study on relations between the population of whitefly (*B. tabaci*) and the incidence of chilli leaf curl virus disease in the field for two consecutive years on cultivar Suryamukhi was made. From the study it was clearly indicated that with the increase of vactor population, there was increase in disease incidence. The maximum increase in vactor population with corresponding increase in disease incidence was observed from third week of February to first week of March during winter season and from first week of April to last week of April during summer season. Significant positive correlation was observed. Correlation coefficient value (r) between whitefly population and disease summer incidence ranged from 0.71 to 0.80 during winter season and from 0.88 to 0.89 during summer season.

Key words : Meterological factors, Whitefly population, chilli leaf curl virus incidence

INTRODUCTION

Chilli (*Capsicum annum* L.) is one of the most important crop in India. In West Bengal, during 1993-94 the crop was grown in 53.8 thousand hectores of area, which produces 42.2 thousand tonnes of dry chillies. The crop suffers from several diseases caused by fungi, bacteria and viruses etc. Leaf curl, a whitefly transmitted virus disease, is the most destructive one. The disease may occur at any stage of plant growth. When the disease appears at an early stage of the growth, the yield reduction upto 80-90% has been observed (Singh *et al.* 1979). Singh *et al.* (1994) have further reported that chilli leaf curl caused by tobacco leaf curl virus causes 40-70% yield loss in Negaland. Saha (2002) reported that the disease is more severe during summer season in comparison to winter season in the plains of West Bengal. Loss of yield goes upto 80% when the plants gets infected early.

The severity of chili leaf curl virus is greatly influenced by a number of factors such as meteorological parameters, vector population, cropping season and varietal susceptibility. Singh *et al.*, (1979) have reproted that the disease spread is more during summer months and this was probably due to high temperature during summer months which is also attributed to the high vector population and disease incidence. Verma *et al.*, (1989) have observed that the incidence of tobacco leaf curl virus on tomato is directly related to the population density of the vector *B. tabaci.* Saikia and Muniyappa (1989) have found that TLCV infection is more in summer (upto 100%) than any other season of the year. A strong correlation is noticed between the percentage incidence of TLCV and wihtefly population. Borah and Bordoloi (1998) have observed that, a positive and significant correlation exists between disease incidence and whitefly population, temperature and rainfall. Many authors (Choen *et al.*, 1988 ; Singh and Tripathi, 1991 ; Polizzi and Asero, 1994) have established a positive correlation between the disease incidence and population size of the vector (*B. tabaci*). Aboul Ata *et al.* (2000) have observed a positive correlation between TLCV intensity and percentage of viruliferous whiteflies.

For adequate control of the disease through control of whiteflies by application of insecticides, a expertise knowledge is required about the buildup of whitefly population in relation to different meteorological factors and disease development. For these reasons a detailed study has been undertaken on influence of different meteorological factors on the build-up of whitefly population and relationship between the population of whitefly and incidence of chilli leaf curl virus disease, as knowledge about these under West Bengal condition are lacking.

MATERIALS AND METHODS

The studies on population dynamics of whitefly (*Bemisia tabaci*) vector in realtion to major environmental factors *viz.* maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall were conducted for two years (during 2000 and 2001). The cultiver Suryamukhi were planted at a spacing of 50 cm × 50 cm for two seasons, winter and summer and was maintained round the year. Recommended agronomic practices were followed excluding the application of pesticides. Vector monitoring was done at fortnightly interval by direct counting on the plants and by placing four yellow sticky trap at crop height in four different plances in the field. In case of direct counting total number of whiteflies from three leaves (from upper, middle and lower) of randomly selected twenty plants were counted and then average number of whitefly per five plants (Y_1) were calculated. In case of yellow sticky trap the number of whiteflies trapped in 24 were recorded for each trap and then average number of whitefly per trap (Y_2) was calculated. Simultaneously observation on meteorological data partiularly maximum temperature (X_1), minimum temperature (X_2), maximum relative humidity (X_3), minimum relative humidity (X_4) and rainfall (X_5) were collected for round the year from All India Co-ordinated Research Project on Agrometeorology (ICAR), BCKV Centre located at Kalyani. Fortnightly average of all these factors were calculated before statistical analysis.

To determine the relationship between different meteorological factors and the vector population, correlation coefficient were worked out inrespet of each meteorological factors and vectors collected from direct counting on plant and yellow sticky trap. Multiple regression was worked out taking meteorological factors as independent variables for determining the combine effect of all these factors on build-up of vector population as outlined by Drapper and Smith (1981). For studying the relationship between the population of whitefly and incidence of chilli leaf curl virus on chilli, the experiments were conducted during winter and summer seasons for two successive years 1999-2000 and 2000-2001. The cultivar Suryamukhi was selected for this study, which is succeptible to leaf curl virus disease. Forty days old seedlings were transplanted in four plots with a spacing of 50 cm × 50 cm. The net plot size was 10 m × 20 m. The crop was grown following the recommended agronomic practices, except the application of any pesticides. The plot was kept under close observation upto 10th March during winter season and 6th June during summer to record the incidence of the disease and the abundance of whitefly population. The diseased plants of chilli leaf curl virus was identified on the basis of symptoms. The weekly obsrvations were taken as per cent of infected plants and the total number of adult whiteflies on the upper, middle and lower leaves of twenty plants (five plants / plot). Statistical analysis of per cent disease incidence data were done after angular transformation. Correlation coefficient was calculated by following the method suggested by Verma *et al.*, (1989), to find out whether there was any relationship between vector population and disease incidence.

RESULTS AND DISCUSSION

The investigation on epidemiology was taken up for two consecutive years (2000 & 2001), primarily to have information on the effects of different meteorological factors on the build up of whitefly population. Data on, fortnightly average of whitefly population ; collected by direct counting from the plant and by yellow sticky trap together with, forthnightly average of maximum and minimum temperature, maximum and minimum relative humidity and rainfall are presented in the Tables 1 & 2.

Table 1 : Meteorological data and white fly (*Bemisia tabaci* Genn.) population in the year 2000.

Month	Tempera-ture (°C)		Relative Humidity (%)		Ranifall (mm)	Whitefly/ five plant	Whitefly/ trap
	Max	Min	Max	Min	Total		
Jan (a)	25.35	9.58	100	53.93	0.00	10	18
Jan (b)	26.26	12.05	99.75	50.63	4.80	11	20
Feb (a)	25.16	11.68	95.86	65.33	24.00	12	25
Feb (b)	26.72	13.32	94.14	39.42	0.00	15	28
Mar. (a)	31.87	19.85	95.80	43.13	0.00	22	32
Mar. (b)	33.23	20.23	92.37	42.50	0.00	23	38
Apr. (a)	35.84	24.58	95.35	49.46	5.30	20	35
Apr. (b)	33.94	23.52	93.60	65.06	83.40	19	33
May (a)	34.43	24.18	94.86	61.00	119.70	18	29
May (b)	34.71	24.41	95.86	68.23	160.90	12	21
Jun. (a)	33.90	23.42	93.60	74.14	94.20	13	27
Jun (b)	32.78	23.44	95.60	77.53	129.90	11	20
Jul. (a)	33.53	26.23	95.60	74.46	40.00	14	26
Jul. (b)	31.21	25.58	97.93	82.68	348.10	6	11
Aug. (a)	33.46	25.96	94.86	76.66	119.20	10	18
Aug. (b)	33.26	25.18	96.06	76.56	132.00	9	14
Sep. (a)	32.18	25.51	96.06	76.06	111.90	10	21
Mean	31.64	21.51	95.76	63.34	80.79	14.12	25.12

A = first fortnight b = second fortnight

Data presented in Table 1 indicated that the whitefly population was observed throughout the year but their number varied in different months. After its appearance on January the population increased rapidly reaching the peak during second fortnight of March and thereafter declined gradually reaching very low population during second fortnight of July and again slightly increased on first fortnight of August.

Table 2 : Meteorological data and white fly (*Bemisia tabaci* Genn.) population in the year 2001.

Month	Tempera-ture (°C)		Relative Humidity (%)		Ranifall (mm)	Whitefly/ five plant	Whitefly/ trap
	Max	Min	Max	Min	Total		
Jan (a)	23.98	9.64	99.53	44.28	0.00	11	17
Jan (b)	26.49	9.18	99.54	34.93	0.00	13	20
Feb (a)	28.70	11.60	95.20	34.07	0.00	16	27
Feb (b)	30.95	17.82	97.84	45.15	6.00	20	30
Mar. (a)	31.79	16.13	94.57	40.76	5.40	22	35
Mar. (b)	35.11	21.61	94.37	43.43	12.90	19	31
Apr. (a)	35.40	23.70	92.33	53.60	9.80	18	29
Apr. (b)	36.32	23.62	90.00	47.84	24.00	15	25
May (a)	33.96	23.19	92.40	65.13	94.70	17	28
May (b)	35.95	25.39	92.18	62.26	60.80	14	24
Jun. (a)	33.32	25.30	96.26	79.85	194.30	11	20
Jun (b)	31.83	25.66	96.26	80.20	120.90	12	22
Jul. (a)	31.61	25.65	96.80	83.00	180.50	10	19
Jul. (b)	31.60	26.10	95.57	83.18	92.40	12	23
Aug. (a)	33.11	25.96	95.18	79.73	75.10	13	20
Aug. (b)	33.25	26.21	97.81	78.25	103.10	13	21
Sep. (a)	32.44	25.39	98.33	78.46	218.10	10	18
Sep. (b)	33.49	25.18	98.00	79.53	115.10	14	24
Oct. (a)	32.89	24.58	99.40	74.33	171.0	13	22
Oct. (b)	31.96	22.75	99.31	70.31	30.80	15	26
Nov. (a)	30.10	21.47	99.13	66.80	3.30	16	29
Nov. (b)	30.88	18.27	98.40	56.66	0.00	16	28
Dec. (a)	28.21	13.08	99.73	52.60	0.00	12.	21
Dec. (b)	25.85	10.57	99.50	50.87	0.00	10	16
Mean	31.63	20.75	96.61	61.80	63.26	16.38	25.25

A = first fortnight, b = second fortnight

In the year 2001 (Table 2), the appearance of whiteflies and their subsequent progress followed more or less similar trend to that of the year 2000.

The peak population of the vector (*B. tabaci*) during the month of March in both the years may be due to the prevalance of high temperature and low rainfall as compared to other months. These findings are in conformity to those of Singh *et al.*, (1979) and Shivanathan (1982). According to them, the high population of whitefly vector during summer months was mainly due to the prevalance of high temperature during that period. The individual effect of different weather factors relating to variation in whitefly population are as follows.

Maximum temperature : Positive insignificant correlation (Table 3) was found between maximum temperature and vector population in the first year

Table 3 : Correlation matrix between vector population and meteorological factors during the year 2000.

	Average no of Whitefly/five Plant (Y_1)	Average no. of Whitefly/trap (Y_2)	Maximum Temperature e (X_1)	Minimum Temperature e (X_2)	Maximum Relative Humidity (X_3)	Minimum Relative Humidity (X_4)	Rain fall (X_5)
X_1	.359	.317	1.000				
X_2	.041	.044	.867**	1.000			
X_3	– .550*	–.605*	–.554*	–.402	1.000		
X_4	–.684**	–.620**	.322	.698**	.088	1.000	
X_5	–.569**	–.593**	.328	.602*	.105	.752**	1.000

Table 4 : Correlation matrix between vector population and meteorological factors during the year 2001.

	Average no of Whitefly/five Plant (Y_1)	Average no. of Whitefly/trap (Y_2)	Maximum Temperature e (X_1)	Minimum Temperature e (X_2)	Maximum Relative Humidity (X_3)	Minimum Relative Humidity (X_4)	Rain fall (X_5)
X_1	.742**	.750**	1.000				
X_2	.352	.383	.867**	1.000			
X_3	– .880*	–.901*	–.554*	–.402	1.000		
X_4	–.217**	–.181**	.322	.698**	.088	1.000	
X_5	–.111**	–.068**	.328	.602*	.105	.752**	1.000

* Significant at P = 0.05 ** Significant at P = 0.01

(2000). But correlation between these two factors was positive and highly significant (Table 4) during the second year (2001). Maxmium number of vector population 23 and 38, from direct count and yellow sticky trap respectively, were observed on second fortnight of March when the average max. temperature was 33.23°C. Again, the whitefly population started to decrease when the average maximum temperture increased up to 34°C and above during the first year (2000). Similar trend was noticed in the year 2001. Maximum number of whitefly from direct count and yellow stricky trap was observed 22 and 35 respectively, on first fortnight of March, when the average maximum temperature was 31.79°C. The whitefly population started to decrease when the average max. temperature increased up to 35°C or above. From the above findings it may be concluded that maxmium number of vector population may be expected when the maximum temperature varied between 31.79°C to 33.23°C.

Minimum temperature : Statistical analysis showed a positive but non significant correlation (Tables 3 & 4) between minimum temperature and the vector population in both the year. Maximum numbers of vectors may be expected between the minimum temperature range of 16.13°C to 20.23°C, above which the population of vector started to decline. From the data presented in the Tables 1 and 2, it was observed that the vector population from June to September was much lower inspite of favourable temperature, which might be due to high rainfall during the period. High ranifall suppressed the effect of other meteorological factos. So we may say from this findings that there was positive relationship between the vector population and temperature but only temperature was not the factor responsible for the build up of vector population.

Maximum relative humidity : Highly significant negative relationship (Tables 3 & 4) between the vector populations and maximum relative humidity was noticed in both the year. Maximum number of vector population was observed during the month of March. From the results presented in the Tables 1 & 2 it is indicated that the maximum number of whiteflies may be expected between the maximum relative humidity range of 92.37% to 94.57%.

Minimum relative humidity : Statistical analysis showed a positive but insignificant correlation (Table 3 & 4) between minimum temperature and the vector population in both the years. Maximum numbers of vectors may be expected between the minimum temperature range of 16.13°C to 20.23°C, above which the population of vector started to decline. From the data presented in the Tables 1 and 2, it was observed that the vector population from June to September was much lower inspite of favourable temperature, which might be due to high ranifall during that period. High rainfall suppressed the effect of other meteorological factors. So it is assumed from this findings that there was positive relationship between the vector population and temperature but only temperature was not the factor responsible for the build up of vector population.

Rain fall : Significant negative correlation was found between the rainfall and whitefly population in the first year (2000), but in the second year (2001), the correlation between these two factors was found to be negative and insignificant (Tables 3 & 4). Maximum vector population in the first year was found on second fortnight of March when the rainfall was zero. More of less similar trend was observed in the second year (Tables 1 & 2).

Multiple regression : The multiple regression equations of vector population due to meteorological factors are expressed by corresponding regression coefficient along with R, R^2, adjusted R^2 and Standard Error Estimates are presented in the Table 5 for both the year under study. From the data presented for in the Table 5, it can be concluded that, maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall are collectively responsible for the build up of vector population in the field. Significant positive correlations were found in between vector populations and different meteorological factors. From the adjusted R^2 value it can be said, these meteorological factors responsible up to 84% and 72.20% for build up of *B. tabaci* recorded from direct count on plant (Y_1) and yellow sticky trap (Y_2) respectively during the first year (2000), though rainfall was most significant parameter for expression of Y_1. During second year (2001) significant positive correlations were also observed between the vector population and meteorological factors. The adjusted R^2 value showed that all the meteorological factors contributed about 90.50% and 92.30% in the build up of vector population recorded by direct count on plant (Y_1) and yellow sticky trap (Y_2) respectively, though the minimum temperative, maximum relative humidity and minimum relative humidity were most significant predictor variables for the performance of both Y_1 and Y_2.

Data on relationship between the population of whitefly (*Bemisia tabaci*) and the incidence of chilli leaf curl virus disease are presented in Tables 6 and 7. In winter 1999-2000, (Table 6) the chilli seedlings were transplanted in the first week of November. The population of whiteflies was found lower on second week of December, which increased slightly on third week of December and again declined on last week of December. From first week of January population of whitefly increased steadily and continued till second week of March, The leaf curl disease was first observed on first week of January followed by slight increase up to third week of January and then increased at higher rate up to last week of February and then declined. The total number of whitefiles per five plants (upper, middle and lower leaves of each plant) in each date of observation during December. January, Febuary and March was found to very from 9-11, 10-12, 13-20 and 22-23 respectively. The average disease incidence in each date of observation during the same period was also obsrved to very from 0, 1-7%, 11-33% and 38-41% respectively.

Table 5 : Multiple regression equations between vector (*Bemisia tabaci*) population and meteorological factors.

Year	Dependent variable	Max. temp (X_1)	Min. temp (X_2)	Max. R.H.(X_3)	Min. (X_5)	Ranifall	Intercept	R. values (%)	R^2 values (%)	Adi R^2 values (%)	S. E. of estimate
2000	Y_1	0.469	0.371	–0.317	–0.328	–0.0149	42.82	0.943	0.89	0.84	2.174
	Y_2	0.688	0.327	–1.191	–0.341	–0.0346	134.78	0.899	0.809	0.722	4.545
2001	Y_1	0.013	0.769*	–0.692**	–0.284**	0.003	84.203	0.962	0.926	0.905	1.437
	Y_2	–0.464	1.459**	–1.257**	–0.481**	–0.0096	160.288	0.969	0.940	0.923	1.993

* Significant at P = 0.05 ** Significant at P = 0.01

Y_1 = Average number of whiteflies per five plants.

Y_2 = average number of whitefiles per trap.

Table 6 : Weekly incidence of whitefly (*Bemisia tabaci*) and leaf curl virus disease of chilli (Suryamukhi) during winter 1999-2000 and 2000-2001.

Date of Observation	Winter 1999-2000			Winter 2000-2001		
	Average no. of whitefly/five plant	Disease incidence (%)[a]	Disease increase (%)	Average no. of whitefly/five plant	Disease incidence (%)[a]	Disease increase (%)
23/12	11	0	0(4.05)	9	0	0(4.05)
30/12	9	0	0(4.05)	7	2	2(8.13)
06/01	10	1	1(5.74)	9	5	3(9.97)
13/01	11	3	2(8.13)	10	8	3(9.97)
20/01	11	4	1(5.74)	12	12	4(11.53)
27/01	12	7	3(9.97)	11	13	1(5.74)
03/02	13	11	4(11.53)	13	15	2(8.13)
10/02	15	17	6(14.17)	13	18	3(9.97)
17/02	17	24	7(15.34)	15	24	6(14.17)
24/02	20	33	9(17.34)	16	31	7(15.34)
03/03	22	38	5(12.92)	19	43	12(20.27)
10/03	23	41	3(9.97)	17	48	5(12.92)
Correlation		0.7053*		Correlation	0.8012**	

[a] = Average of three replications

Figures within the parenthesis are angular transformed values.

* Significant at P = 0.05 ** significant at P = 0.01

In winter 2000-2001, (Table 6) the cillli seedlings were transplanted on the same date (first week of November). The appearance of whitefiles followed the similar treand to that of winter 1999-2000. The leaf curl disease was first observed on last week of December followed by a slight rise up to third week of January and then declined abruptly on last week of January. Again the disease increased steadily from first week of February and continued up to first week of March. The total number of whiteflies per five plants in each date of observation during December, January, February and March was found to vary from 7-9, 9-12, 13-16 and 17-19 respectively. The avrage disease incidence in each date of observation during the same period was also observed to vary from 0-2%, 5-13%, 15-31% and 43-48% respectively.

In summer 2000 (Table 7), the chilli seedlings were transplanted in the second week of February. The population of whiteflies found on third week of March was higher than the winter season, which increased gradually reaching the peak population during first week of April. After that the population declined slightly and continued up to first week of June. The leaf curl disease incidence was first observed on third week of March and incidence increased at increasing rate up to first week of April and thereafter the disease incidence increased at decreasing rate continuously up to third week of May. The total number of whitefly population per five plants in each date of observation during March, April, May and June was found to vary from 22-23, 18-025, 12-18 and 11 respectively. The average disease incidence in each date of observation during March, April, May and June was found to vary from 3-8%, 17-34% and 45% respectively.

In summer, 2001 (Table 7), the chilli seedlings were transplanted on the same date (second week of November). The population of whitefiles followed more or less similar trend that of summer 2000 but in this case the increasing trend continued up to last week of April and thereafter the population declined gradually up to third week of May. Again, in the last week of May the population increased slightly and then declined. The total number of whitefly population per five plants in each date of observation during March, April, May and June was found to vary from 21-24, 25-27, 19-25 and 18 respectively. The average disease incidence for each date of observation during March, April, May and June was found to vary from 1-4%, 8-22%, 40-52% and 52% respectively.

A significant positive correlation was found when the data on the population of whitefly and the incidence of chilli leaf curl virus disease were analyzed statistically during both the year *i.e.*

Table 7 : Weekly incidence of whitefly (*Bemisia tabaci*) and leaf curl virus disease of chilli (Suryamukhi) during summer 2000-2001.

Date of Observation	Summer, 2000			Summer, 2001		
	Average no. of whitefly/five plant	Disease incidence (%)[a]	Disease increase (%)	Average no. of whitefly/five plant	Disease incidence (%)[a]	Disease increase (%)
21/03	22	3	3(9.97)	21	1	1(5.74)
28/03	23	8	5(12.92)	24	4	3(9.97)
04/04	25	17	9(17.46)	25	8	4(11.53)
11/04	21	24	7(15.34)	25	14	6(14.17)
18/04	19	30	6(14.18)	26	22	8(16.43)
25/04	18	34	4(11.54)	27	33	11(19.36)
02/05	18	37	3(9.97)	25	40	7(15.34)
09/05	16	40	3(9.97)	23	45	5(12.92)
16/05	15	42	2(8.13)	20	48	3(9.97)
23/05	12	43	1(5.74)	19	50	2(8.13)
30/05	13	45	2(8.13)	21	52	2(8.13)
06/06	11	45	0(4.05)	18	52	0(4.05)
Correlation	0.8846**			Correlation	0.8913**	

[a] = Average of three replications
Figures within the parenthesis are angular transformed
** Significant at P = 0.01

winter 1999-2000 (r = 0.7053), winter 2000-2001(r = 0.8012), summer 2000 (r = 0.8846) and summer 2001 (r = 0.8913). In the present studies a good correlation between the population density of whitefly and incidence of chilli leaf curl virus disease was observed in the plains of West Bengal. The above findings are in close agreement with the findings of Singh *et al.* (1979) that the incidence of chilli leaf curl virus disease was dependent on vector (*B. tabaci*) population. The increase or decrease in the incidence and spread of chilli leaf curl virus disease was found to be directly correlated with the increase and decrease in whitefly population (Singh *et al.*, 1994).

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