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Associationship of whitefly population and weather variables at different yellow sticky trap height in soybean: A correlation and regression approach

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ABSTRACT

In the present paper the prediction of average number of soybean whitefly at various yellow sticky trap height has been performed using the meteorological data namely maximum and minimum temperature, relative humidity morning and evening, wind velocity, vapour pressure morning and evening, rainy days and sunshine hrs. with the help of correlation and regression approach. The various prediction models have been developed using a combination of meteorological variables at different trap height which provides the value of R^2 from 14 to 54 per cent playing their important role in the prediction. A combination of meteorological parameters namely maximum and minimum temperature, relative humidity morning and evening, rainfall, sunshine hours and wind velocity are found to be more influential variable to attract soybean whitefly explaining 54 per cent variability towards observation of whitefly.

***Keywords*:** Correlation and regression, prediction models and whitefly

Soybean (*Glycine max* (L.) Merrill) has been established as an industrially vital and economically viable oilseed crop in many areas of India. It is triple beneficiary crop, unique food, valuable feed, and an industrial raw material with considerable potential. Soybean ranks first in world oil production and is cheap source of protein for food and feed. Soybean is also known as poor man's meat. Now a days, there is vast scope for soybean production due to high nutritional quality, more production and availability of short duration varieties (90-110 days), to tolerate long dry spell and being leguminous crop, helps in improving the soil fertility and productivity of soil. Soybean helps in building up the soil fertility by fixing atmospheric nitrogen through the root nodules. Hence, it is known as "gold of soil."

The area, production and productivity in the world for 2016-17 were 116.50 Lakh ha. 80.00 lakh tonnes and 687 kg ha^{-1} respectively (SOPA, 2016):- while in India, it was 11.47 million (M) ha, 9.7 million metric tonnes (MMT) and 0.84 metric tonnes (MT) ha^{-1}, respectively and has ranked 5th in area, production and productivity of soybean in the world after USA, Brazil, Argentina and China.

There has been a decline in the soybean yield due to various problems in the field, of which whitefly, *Bemisia tabaci* Genn. (Hemiptera : Aleyrodidae) is one of the most important cosmopolitan sucking pest that reduces severe yield losses of 85-100 21per cent depending upon the susceptibility of the cultivar, time of infection, and other favorable conditions (Marabi *et al.*, 2017).

Some of the researchers worked in this direction are Ahirwar (2013), Alam and Patidar (2014), Bhowmik (2016), Gaur *et al*. (2012), Gopaldas (2017), Kalyan and Ameta (2017), Netam (2010) and Netam *et al*. (2013).

The objective of the present paper is to correlate the meteorological parameters with the pattern of whitefly and prediction of whitefly at various stages of yellow sticky trap height on the basis of the data gathered from an experiment of entomology, 2017.

A trial was conducted at Dusty acre, well known farm of JNKVV experimental area in 10,000 hectare with soybean crops (variety JS-97-52) having row to row distance 45 cm. and plant to plant 10 to 15 cm during 2015-16. The occurrence of the pest specially whitefly was observed at various trap height 3, 5, 10, 15, 25 and 50 feet respectively from base of the plant. Then the observed data were gathered weekly and analysed for drawing conclusions.

Correlation is a statistical technique that indicates a degree of linear relationship between two variables. That is how strongly pairs of variables are linearly related to each other. Correlation coefficient measures the intensity between two variables. In this analysis, the dependent variable is the mean population of soybean whitefly (say Y) depends on the independent variables which were the weather parameters (X_1-maximum temperature, X_2-minimum temperature, X_3-relative humidity morning, X_4-relative humidity evening, X_5-rainfall, X_6-sunshine, X_7-wind speed, X_8-vapor pressure morning, X_9-vapor pressure evening and X_{10}-rainy days). The correlation coefficient between random variables X and Y usually denoted by

$$\mathbf{r\ (X,Y)} = \frac{\mathrm{Cov(X,Y)}}{\sigma x \sigma y} \quad \frac{\frac{1}{n}\sum XY - \overline{X}\overline{Y}}{\sqrt{\left(\frac{1}{n}\sum X^2 - \overline{X}^2\right)\left(\frac{1}{n}\sum Y^2 - \overline{Y}^2\right)}}$$

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Multiple regression analysis has become one of the most widely used statistical tools for analyzing functional relationship among the variables, which is expressed in the form of equation connecting the dependent variable and one or more independent variables. In this context, the various multiple regression models were used in order to assess the effect the independent variables towards the mean population of soybean whitefly including coefficient of determinations R^2 and ANOVA table.

Specifically, the regression model was written in the following form

$$\mathbf{Y_i = b_o + \sum_{j=1}^{10} Xji + \Sigma_i}$$

The results of the present work for describing the correlation coefficients of soybean whitefly with meteorological parameters and the proposed multiple regression lines were fitted to the data taken from the field of Department of Entomology, J.N.K.V.V. Jabalpur during *Kharif* 2017-2018 crop season and the statistical parameters of these soybean population shown in the respective table for different days of observation.

The correlation coefficients between soybean whitefly at various trap height with maximum and minimum temperature were found to be mostly highly significant correlation followed by morning relative humidity, wind velocity, particular at higher trap heights. It shows that maximum and minimum temperature plays an important role in attracting whitefly population at any trap height which was vividly explainable through the value of R^2 during the experimentation.

Multiple regression analysis

The regression equation for the expectation of average population of soybean whitefly per trap was obtained by least square method. The standard error of the estimated coefficients was obtained from the variance-covariance matrix. The combination of the independent variable had been tested by means of the student t test.

In order to observe, the contribution of individual meteorological variables, a regression line was fitted and computed the value of R^2.

At the occurrence of soybean whitefly at 3ft-R_1 the important meteorological variables described the variability in the average number of soybean whitefly by maximum temperature (27%) followed by minimum temperature (19%), wind velocity (11%), relative humidity morning (10%), rainy days (7%), vapour pressure morning (6%) and lastly sunshine (5%). Theses have been concluded through the value of correlation coefficient and the value of R^2.

It indicated that maximum temperature, minimum temperature and wind velocity contributed the inherent variability of occurrence of soybean whitefly almost 27, 19 and 11 per cent, respectively. The meteorological parameters maximum temperature and minimum temperature were highly correlated. After deleting the high value of correlation coefficients to avoid the multi collinearity, a regression equation along with ANOVA table for the 3ft-R_1 are given below. The regression coefficients of the factor X_1, X_2, X_3, X_6, X_7, X_8 and X_{10} are found to be non-significant through the value of t statistic. Since t statistic is the ratio of concern regression coefficient to the standard error. The value of F statistic was also found to be significant.

$$\hat{Y}_1 = -67.300 + 2.188X_{1i} - 1.603X_{2i} + 0.260X_{6i} + 0.949X_{7i} + 1.585X_{8i} + 1.151X_{10i}$$

(1.334) (1.467) (1.574) (1.892) (1.190) (1.274)

The value of R^2 is 40 per cent for this model and F value was significant.

Then considering the other variables the regression equation was obtained given below:

$$\hat{Y}_1 = 64.389 - 3.175X_{2i} - 1.042X_{3i} + 0.885X_{6i} - 0.324X_{7i} + 4.814X_{8i} + 1.310X_{10i}$$

(1.954) (0.519 (1.200) (1.874) (2.466) (1.194)

The value of R^2 is 42 per cent for this model and F value was significant.

At the occurrence of soybean whitefly at 3ft-R_2 the contribution of meteorological parameters explained firstly inherent variability of maximum temperature (26%) towards soybean whitefly followed by minimum temperature (18%), wind velocity (11%), relative humidity morning (10%), rainy days (10%), vapour pressure morning (5%) and sunshine (4%).

It indicated that maximum temperature, minimum temperature and wind velocity contributed the inherent variability of occurrence of soybean whitefly almost 26, 18 and 11 per cent, respectively. The meteorological parameters maximum temperature and minimum temperature were highly correlated. After deleting the high value of correlation coefficients to avoid the multi collinearity, a regression equation along with ANOVA table for the 3ft-R_2 are given below. The regression coefficients of the factor X_3 is found to be significant through the value of t statistic. Since t statistic is the ratio of concern regression coefficient to the standard error. The value of F statistic was also found to be significant.

$$\hat{Y}_1 = -90.755 + 3.202X_{1i} - 2.247X_{2i} - 0.238X_{6i} + 0.908X_{7i} + 1.936X_{8i} + 2.236X_{10i}$$

(1.718) (1.889) (2.027) (2.436) (1.533) (1.640)

The value of R^2 is 42 per cent for this model and F value was significant.

Table 1: Correlation coefficient of whitefly population at different trap height with weather parameters

	Trap height (ft) from base of plant	Meteorological parameter									
		Max. temp (^{0}C)	Min. temp (^{0}C)	Morning vapour pressure (mm)	Evening vapour pressure (mm)	Morning RH (%)	Evening RH (%)	Wind velocity (km hr^{-1})	Sun shine (hrs)	Rainfall (mm)	(No. of rainy days)
Correlation	3ft-R1	0.522**	0.44**	0.242	0.141	-0.323*	-0.093	0.331*	0.231	-0.057	0.261
	3ft-R2	0.513**	0.43**	0.235	0.145	-0.320*	-0.083	0.339*	0.194	-0.016	0.322*
	5ft-R1	0.501**	0.398*	0.197	0.106	-0.339*	-0.118	0.298	0.213	-0.081	0.207
	5ft-R2	0.524**	0.442**	0.220	0.138	-0.354*	-0.089	0.321*	0.205	-0.028	0.186
	10ft-R1	0.390*	0.423**	0.307	0.235	-0.187	0.029	0.262	0.135	-0.020	0.219
	10f-R2	0.414**	0.377*	0.243	0.140	-0.238	-0.058	0.324*	0.133	-0.044	0.269
	15ft-R1	0.218	0.363*	0.349*	0.308	-0.013	0.161	0.112	0.059	0.017	0.127
	15ft-R2	0.299	0.310	0.237	0.168	-0.150	0.006	0.197	0.135	0.000	0.200
	25ft-R1	0.474**	0.48**	0.292	0.216	-0.285	-0.003	0.383**	0.161	-0.035	0.233
	25ft-R2	0.506**	0.466**	0.251	0.170	-0.325*	-0.054	0.412**	0.193	-0.040	0.268
	50ft-R1	0.625**	0.37*	-0.094	-0.104	-0.654**	-0.290	0.349*	0.272	-0.125	0.006
	50ft-R2	0.636**	0.418**	-0.043	-0.058	-0.639**	-0.260	0.406*	0.258	-0.140	0.044

*Note: *Significant at p=0.05 level, **Significant at p=0.01 level*

Table 2: Analysis of variance table

Source of variation	df	SS	MS	F	R^2
Regression($X_1,X_2,X_6,X_7,X_8,X_{10}$)	6	2029.633	338.272	3.534	0.399
Residual	32	3062.944	95.717		
Regression($X_2,X_3,X_6,X_7,X_8,X_{10}$)	6	2143.526	357.254	3.877	0.421
Residual	32	2949.051	92.158		
Total	38	5092.577			

Table 3: Analysis of variance table

Source of variation	df	SS	MS	F	R^2
Regression($X_1,X_2,X_6,X_7,X_8,X_{10}$)	6	3685.603	614.267	3.869	0.420
Residual	32	5079.871	158.746		
Regression($X_2,X_3,X_6,X_7,X_8,X_{10}$)	6	3819.397	636.566	4.118	0.436
Residual	32	4946.077	154.565		
Total	38	8765.474			

Table 4: Analysis of variance table

Source of variation	df	SS	MS	F	R^2
Regression(X_1,X_2,X_4,X_5,X_7)	5	205.570	41.114	4.337	0.397
Residual	33	312.827	9.480		
Regression(X_2,X_3,X_5,X_6,X_7)	5	282.233	56.447	7.887	0.544
Residual	33	236.165	7.157		
Total	38	518.398			

Table 5: Analysis of variance table

Source of variation	df	SS	MS	F	R^2
Regression(X_1,X_2,X_4,X_5,X_7)	5	221.870	44.374	4.896	0.426
Residual	33	299.105	9.064		
Regression(X_2,X_3,X_5,X_6,X_7)	5	278.681	55.736	7.591	0.535
Residual	33	242.293	7.342		
Total	38	520.974			

Then considering the other variables the regression equation was obtained given below:

$$\hat{Y}_1 = 92.882 - 4.169X_{2i} - 1.416X_{3i} + 0.820X_{6i} - 0.873X_{7i} + 6.167X_{8i} + 2.541X_{10i}$$
$$\quad (2.530) \quad (0.672) \quad (1.554) \quad (2.427) \quad (3.194) \quad (1.546)$$

The value of R^2 is 44 per cent for this model and F value was significant.

At the occurrence of soybean whitefly at 50ft-R_1 the important meteorological variables described the variability in the average number of soybean whitefly by relative humidity morning (42%) followed by maximum temperature (38%), minimum temperature (14%), wind velocity (11%), relative humidity evening (8%), sunshine (7%) and rainfall (1%).

It indicated that relative humidity morning, maximum temperature and minimum temperature contributed the inherent variability of occurrence of soybean whitefly almost 42, 38 and 14 per cent, respectively. The meteorological parameters relative humidity morning and maximum temperature were highly correlated. After deleting the high value of correlation coefficients to avoid the multicollinearity, a regression equation along with ANOVA table for the 50ft-R_1 are given below. The regression coefficients of the factor X_2 and X_3 are found to be significant through the value of t statistic. Since t statistic is the ratio of concern regression coefficient to the standard error. The value of F statistic was also found to be significant.

$$\hat{Y}_1 = -11.371 + 0.387X_{1i} + 0.011X_{2i} - 0.012X_{4i} - 0.001X_{5i} + 0.226X_{7i}$$
$$\quad (0.695) \quad (0.566) \quad (0.154) \quad (0.015) \quad (0.479)$$

The value of R^2 is 40 per cent for this model and F value was significant.

Then considering the other variables the regression equation was obtained given below;

$$\hat{Y}_1 = 20.757 + 0.272X_{2i} - 0.190X_{3i} - 0.007X_{5i} - 0.655X_{6i} - 0.949X_{7i}$$
$$\quad (0.117) \quad (0.043) \quad (0.012) \quad (0.326) \quad (0.516)$$

The value of R^2 is 54 per cent for this model and F value was significant.

At the occurrence of soybean whitefly at 50ft-R_2 the important meteorological variables described the variability in the average number of soybean whitefly by maximum temperature (39%) followed by relative humidity morning (39%), minimum temperature (16%), wind velocity (16%), relative humidity evening (7%), sunshine (6%) and rainfall (2%).

It indicated that maximum temperature, relative humidity morning and minimum temperature contributed the inherent variability of occurrence of soybean whitefly almost 39, 39 and 16 per cent, respectively. The meteorological parameters maximum temperature and relative humidity morning were highly correlated. After deleting the high value of correlation coefficients to avoid the multicollinearity, a regression equation along with ANOVA table for the 50ft-R_2 are given below. The regression coefficients of the factor X_2 and X_3 are found to be significant through the value of t statistic. The value of F statistic was also found to be significant.

$$\hat{Y}_1 = -7.989 + 0.239X_{1i} + 0.135X_{2i} - 0.034X_{4i} - 0.005X_{5i} + 0.292X_{7i}$$
$$\quad (0.679) \quad (0.553) \quad (0.150) \quad (0.015) \quad (0.468)$$

The value of R^2 is 43 per cent for this model and F value was significant.

Then considering the other variables the regression equation was obtained given below;

$$\hat{Y}_1 = 17.082 + 0.280X_{2i} - 0.165X_{3i} - 0.012X_{5i} - 0.561X_{6i} - 0.696X_{7i}$$
$$\quad (0.118) \quad (0.044) \quad (0.012) \quad (0.330) \quad (0.522)$$

The value of R^2 is 54 per cent for this model and F value was significant.

The maximum and minimum temperature, relative humidity morning, wind velocity and vapour pressure morning had played an important role for governing the occurrence of whitefly on soybean crop at various trap heights. A combination of meteorological parameters namely maximum and minimum temperature, relative humidity morning and evening, rainfall, sunshine hours and wind velocity were found to be more influential variable to attract soybean whitefly explaining 54% variability towards observation of whitefly.

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