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MODELS FOR FORECASTING INCIDENCE OF GARLIC MITES IN JABALPUR DISTRICT OF MADHYA PRADESH, INDIA

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ABSTRACT

This study was to describe the applicability of correlation, multiple regression procedure, ANOVA, t-test have been applied on raw data of incidence of average mites' population on garlic crop. The data was collected from Department of Entomology, J.N.K.V.V., Jabalpur (M.P.), India. The multiple regression procedure has been applied to study the pattern of seasonal fluctuations of garlic mites through prediction models at different transplanting periods. Maximum temperature, vapor pressure, relative humidity, wind speed, evaporation and rainfall had played an important role for governing the population of garlic mites at different date of transplanting.

Key words : Garlic, Correlation coefficient, Regression coefficient.

Introduction

Garlic (*Allium sativum*) is a species in the onion genus, Allium. Its close relatives include the onion, shallot, leek, chive and Chinese onion. It is a native to Central Asia and north-eastern Iran, and has long been a common seasoning worldwide, with a history of several thousand uses. It was known to ancient Egyptians and has been used both as a food flavouring and as a traditional medicine. China produces some 80% of the world's supply of garlic.

Garlic (*Allium sativum*) is one of the important bulb crops grown and used as a spice or condiment throughout India. It is also important foreign exchange earner for India. It is consumed by almost all people who take onion. Garlic has higher nutritive value than other bulb crops. It is rich in proteins, phosphorous, potassium, calcium, magnesium and carbohydrates. Ascorbic acid content is very high in green garlic.

Aceria tulipae is one of the most damaging mite pests of garlic. The mite causes devastating damage to stored garlic also. Mite population initiated at the end of December and attained maximum numbers during mid-February. They can reduce stands, slow plant vigor and increase post-harvest diseases. (Onkarappa, 1999). Bulb mites have a very wide host range, but cause most of their damage to onions and garlic. Species from the genera *Rhizoglyphus* and *Aceria* are the most common garlic parasitic mites, with the latter being known as the dry bulb mite (Pruthi, 1969).

Bulb mites can overwinter in soil and also survive in stored garlic. They can damage garlic in the field, but are particularly troublesome in storage. Their feeding can cause desiccation and creates wounds that provide ingress for bacteria and pathogenic fungi such as *Fusarium* and *Penicillium*. In the field, mites are usually not seen on the bulb but feed mainly on the roots and basal plate. In storage, mites move into the garlic bulb (Prasanna, 2007).

Materials and Methods

The data were gathered from Department of Entomology based on Garlic Thrips and mite's incidence during the year 2011-12 and weather collected from

Department of Agro-Meteorology of the same year. For conducting analysis of incidence of thrips and mites in Garlic crop 2 transplanting dates 1st October 2012, 15th October 2012, 1st November 2012, 15th November 2012, 1st December 2012, 15th December 2012, 1st January 2012, 15th January 2012.

Correlation analysis

Correlation is a bivariate analysis that measures the strength of association between two variables and the direction of relationship. In terms of the strength of relationship, the value of the correlation coefficient varies between +1 and -1. A value of ±1 indicates a perfect degree of association between the two variables. In statistics, we measure four types of correlations; Pearson correlation, Kendall rank correlation, Spearman correlation and the Point – Biserial correlation. In this analysis we used Pearson correlation.

Pearson correlation : Pearson r correlation is used to measure the degree of relationship between the two variables. In this analysis, the dependent variable (Y) is taken as the average number of thrips per 5 plant and independent variable (X) is taken as the weather parameters such as maximum temperature, minimum temperature, vapour pressure, relative humidity, wind speed etc. The following formula is used to calculate the Pearson r correlation:

$$r = \frac{\operatorname{cov} XY}{\sigma x \sigma y} = \frac{N\Sigma xy - \Sigma x \Sigma y}{\sqrt{[N\Sigma x2 - \Sigma(x)2][N\Sigma y2 - \Sigma(y)2]}}$$

where,

r = Pearson r correlation coefficient

N = number of observations corresponding Meteorological standard week.

Σx = sum of the average weather parameters data having x1 as max. temperature, x2 as min. temperature and so on according to the number of parameters.

Σy = sum of the average thrips population taken according to the transplanting date corresponding meteorological standard week.

Σxy = sum of the product of the above two variables.

Σx2 = sum of squares of x variables.

Σy2 = sum of squares of y variables.

Significance test

To test whether the association is merely apparent, and might have arisen by chance we use the t-test in the following calculation:

$$t = r\sqrt{n-2/1-r^2}$$

Where,

r = correlation coefficient and n = number of observations.

Regression analysis

In statistical modeling, regression analysis is a set of statistical processes for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables (or 'predictors').

Models: Regression models involve the following parameters and variable:

- The unknown parameters, denoted as β, which may represent a scalar or a vector.
- The independent variable, X.
- The dependent variable, Y.

A regression model related Y to a function of X and β Y ~ f (X, β)

Multiple Linear Regression Models

In this analysis we used multiple linear regression model followed by least square method. In this model, there are several independent variables as weather factors or functions of these variables.

Yi = β0 + β1xi + β2xi + εi,i = 1, 2, 3…….10

where, Yi = ith observation of the average week mean population

β0 and β1 = parameters of model to be estimated

xi = independent weather factors.

The description of these weather parameters attributing incidence on Garlic thrips are given below:

X1 = Maximum Temperature (°C)

X2 = Minimum Temperature (°C)

X3 = Morning Vapour Pressure (mm)

X4 = Evening Vapour Pressure (mm)

X5 = Mor. Relative Humidity (%)

X6 = Eve. Relative Humidity (%)

X7 = Wind Speed km/hr

X8 = Sunshine hours

X9 = Rainfall (mm)

X10 = Evaporation (mm)

Coefficient of Multiple Determinations (R^2)

R-squared is a statistical measure of how close the data are to the fitted regression line. It is also known as the coefficient of determination, or the coefficient of multiple determinations for multiple regressions. It is the percentage of response variable that is explained by a linear model. Or:

R-squared = Explained variation/ Total variation.

R-squared is always between 0 and 100%.

- 0% indicates that the model explains none of the variability of the response data around its mean.
- 100% indicates that the model explains all the variability of the response data around its mean. In general, the higher the R-squared, the better the model fits your data.

Square Root Transformation:

Square Root Transformation is used for count data consisting of small whole numbers and the data, where the data ranges either between 0 to 30% and 70 to 100%. Data obtained from counting the rare events like number of infected plants due to thrips where square root transformation can be used before taking up analysis of variance to draw a meaningful conclusion or inference. If most of the values in a data set are small (less than 10) coupled with presence of zero values. Instead of using $\sqrt{x}$ transformation it is better to use$5\sqrt{x} + 0.5$. Then Analysis of Variance to be conducted with transformed data and the mean table should be made from the transformed data instead of taking the mean from original data because of the facts stated earlier.

Analysis of Variance

Analysis of variance (ANOVA) is a collection of statistical models and their associated estimation procedures (such as the "variation" among and between groups) used to analyze the difference among group means in a sample. This technique enables us to break down the variance of the measured variables into the portions caused by the several factors, varied singly or in combination and a portion caused by experimental error.

The assumptions of the analysis of variance are:

- Observations are random with respect to any conditions.
- Means and variances of measured variables are additive.
- Experimental errors are independent.
- Variances of the experimental errors (eij) for all pairs (i, j) are equal with common value σe 2.
- Distribution of experimental errors is normal.

Model

There are three classes of models used in analysis of variance. But in this analysis of Garlic thrips incidence, we used Fixed-effects models.

The Fixed-effects model (class I) of analysis of variance applies to situation in which the experimenter applies one or more treatments to the subjects of the experiment to see whether the response variable values change. This allows the experimenter to estimate the ranges of response variable values that the treatment would generate in the population as a whole.

In this analysis of variance, the two-way classified data will be employed to find out the effect of different plant protection approaches over the meteorological weeks, it can be shown by mathematical fixed effect model given below:

$y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$; i = 1, 2….m

where,

y_{ij} = effect of the j^{th} value of the meteorological data under i^{th} level of plant protection approach.

μ = general mean effect.

α_i = effect of i^{th} level of plant protection approach or treatments (i = 1, 2…4).

β_j = effect of j^{th} level of the data of particular meteorological data (j = 1, 2….10).

e_{ij} = is the error which are supposed to be normally, independently and identically distributed with zero mean and σe 2.

Results and Discussion

The result emanated from the data considered under the purview of this investigation are presented as follows: Table 1 was showing the degree of association between the increases in average Garlic thrips population due to different weather conditions. To test whether the association was merely apparent and might have arisen by chance, we preformed t-test. The test gave significant values in some of the transplanting dates which was shown by '*' for significance at 5% level and '**' for significance at 5% and 1% both. At 1st November Transplanting date thrips population was significantly and positively correlated with maximum temperature and Evaporation while the other correlations were found to be non-significant. On 15th November Transplanting date thrips population was significantly and positively correlated with Evaporation and negatively correlated with morning relative humidity. On 1st December Transplanting date thrips population was significantly and positively correlated with maximum temperature and Evaporation and negatively correlated with morning relative humidity. Similarly, at 15th December Transplanting date evaporation is negatively correlated

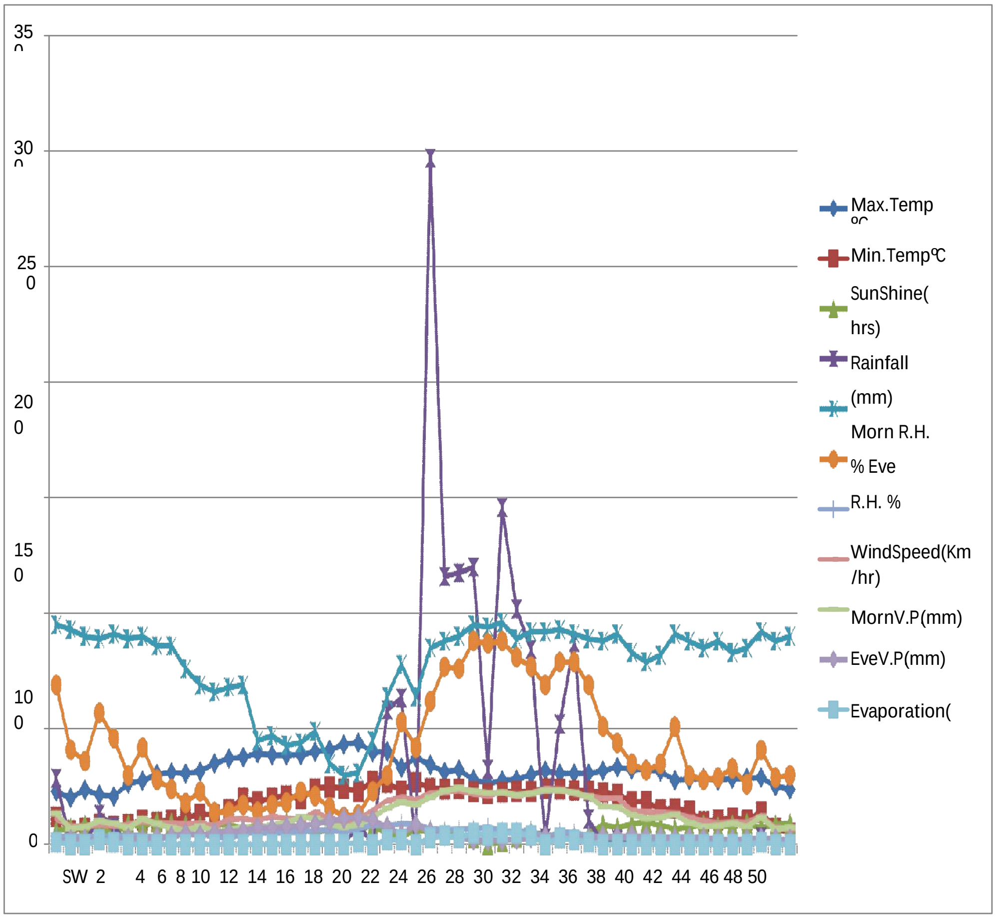

Fig. 1 : Changing pattern of Meteorological data during the Garlic crop season of the year 2011-12.

Table 1 : Correlation coefficient of Mean mites population with meteorological parameters in Garlic crop.

	Temp (Max)	**Temp (Min)**	**Sunshine (hr)**	**Rainfall (mm)**	**RH (Morning)**	**RH (Evening)**	**Wind Speed (km/h)**	**V.P (Morning)**	**V.P (Evening)**	**Evaporation (mm)**	**Rainy days**
Oct 1	0.59	0.348	0.065	-0.32	-0.608	-0.222	0.502	0.181	0.073	0.453	-0.02
Oct 15	0.564	0.344	0.077	-0.309	-0.646	-0.196	0.494	0.168	0.078	0.455	0.035
Nov 1	.759*	0.236	0.403	-0.42	-.767*	-0.593	-0.166	0.053	-0.109	.729*	-0.263
Nov 15	.844**	.0302	0.489	-0.483	-0.661	-0.608	-0.05	0.176	-0.037	.716*	-0.459
Dec 1	.810*	0.264	0.442	-0.476	-0.668	-0.626	-0.057	0.123	-0.084	.710*	-0.436
Dec 15	.829*	0.304	0.466	-0.482	-0.642	-0.593	-0.031	0.181	-0.022	0.0692	-0.453
Jan 1	.891**	.777*	0.607	-0.41	-769*	-0.618	-0.704	0.750*	0.101	.827*	-0.4
Jan 15	.778*	0.571	0.53	-0.306	-.813*	-0.688	-.843*	0.415	-0.252	.859**	-0.3

with the thrips population remaining others is non-significant. Similarly, at 1st January Transplanting date Minimum temperature and morning vapor pressure are significantly and positively correlated with the thrips population, while evening relative humidity is negatively correlated, remaining others are non significant. At 15th January Transplanting minimum temperature is significantly and positively correlated and negatively and morning relative humidity and wind speed significantly and negatively correlated with the thrips population remaining others non-significant (Hole and Salunkhe, 1997).

At 1st November Transplanting date mites' population was significantly and positively correlated with maximum temperature and Evaporation, and negatively 28 correlated with morning relative humidity while the other correlations were found to be non-significant.

On 15th November Transplanting date mites' population was significantly and positively correlated with

Table 2 : Correlation coefficients among the weather variables at 1st October Transplanting period.

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Y	1											
X1	0.590	1										
X2	0.348	0.318	1									
X3	0.065	0.638	-0.374	1								
X4	-0.320	-0.292	0.688	-0.633	1							
X5	-0.608	-0.394	0.328	-0.511	0.621	1						
X6	-0.222	-0.361	.717*	-0.694	.935**	0.606	1					
X7	0.502	0.065	0.393	-0.202	-0.093	.0.031	0.090	1				
X8	0.181	0.276	.967**	-0.346	0.700	0.508	.742*	0.368	1			
X9	0.073	0.116	.881**	-0.472	.820*	0.468	.858**	0.020	.893**	1		
X10	0.453	0.601	-0.440	.834*	-.851**	-.801*	-.877**	0.076	-0.511	-0.677	1	
X11	-0.020	-0.485	0.396	-0.649	0.694	0.045	.752*	-0.016	0.289	0.521	-0.586	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Table 3 : Regression coefficients of the model of mites' population with meteorological parameters in Garlic crop (X1, X5, X7).

Model	Coefficients	Std. Error	t-value Constant
Constant	63.443	52.647	1.205
X1	0.581	0.426	1.366
X5	0.934	0.528	-1.770
X7	3.515	1.774	1.981

The regression equation was obtained as follows:

$$\hat{Y}_i = 63.443 + 0.581\,X_1 - 0.934\,X_5 + 3.515X_7$$
$$(0.426) \quad (0.528) \quad (1.774)$$

Evaporation, while the other correlations were found to be non significant.

On 1st December Transplanting date mites' population was significantly and positively correlated with maximum temperature and Evaporation, while the other correlations were found to be non-significant.

At 15th December Transplanting date maximum temperature is significantly and positively correlated with the mite's population remaining others are non-significant.

At 1st January Transplanting date minimum temperature, morning vapor pressure and evaporation are significantly and positively correlated and morning relative humidity is negatively correlated with the mite's population remaining others are non-significant.

Table 4 : Analysis of Variance of regression model of mean mites population of Garlic crop on X1, X5, X7.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	89.203	3	29.734	4.108	6.590	0.755
Residual	28.955	4	7.239			
Total	118.158	7				

Table 5 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X1, X2, X10).

Model	Coefficients	Std. Error	t-value
Constant	-14.738	11.902	-1.238
X1	-0.554	1.056	-0.524
X2	1.706	1.093	1.561
X10	8.832	5.821	1.517

The regression equation was obtained as follows:

$$\hat{Y}_i = -14.738 - 0.554X1 + 1.706X2 + 8.832X10$$
$$(1.056) \quad (1.093) \quad (5.821)$$

At 15th January Transplanting morning temperature is positively correlated and morning relative humidity is negatively correlated with the mite's population remaining others are non-significant.

Since, Fcal< Ftab the null hypothesis was accepted and there were no significant difference among the variables. And R^2 i.e. coefficient of determination was 75%. Table 4 ANOVA was showing the weather variable combinations as X1 (Maximum Temperature), X5 (Morning Relative Humidity) and X7 (Wind Speed) were taken into consideration for predicting the Mites population

Table 6 : Analysis of Variance of regression model of mean mites population of Garlic crop on X1, X2, X10.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	71.380	3	23.793	2.035	6.590	0.604
Residual	46.777	4	11.694			
Total	118.158	7				

Table 7 : Correlation coefficients among the weather variables at 15 th October Transplanting period.

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Y	1											
X1	0.564	1										
X2	0.344	0.318	1									
X3	0.077	0.638	-0.374	1								
X4	-0.309	-0.292	0.688	-0.633	1							
X5	-0.646	-0.394	0.328	-0.511	0.621	1						
X6	-0.196	-0.361	.717*	-0.694	.935**	0.606	1					
X7	0.494	0.065	0.393	-0.202	-0.093	0.031	0.090	1				
X8	0.168	0.276	.967**	-0.346	0.700	0.508	.742*	0.368	1			
X9	0.078	0.116	.881**	-0.472	.820*	0.468	.858**	0.020	.893**	1		
X10	0.455	0.601	-0.440	.834*	-.851**	-.801*	-.877**	0.076	-0.511	-0.677	1	
X11	0.035	-0.485	0.396	-0.649	0.694	0.045	.752*	-0.016	0.289	0.521	-0.586	1

**.Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

Table 8 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X4, X5).

Model	Coefficients	Std. Error	t-value
Constant	81.195	42.141	1.927
X2	1.801	0.465	3.876
X4	-0.271	0.122	-2.228
X5	-0.993	0.459	-2.161

The regression equation was obtained as follows:

$$\hat{Y}_i = 81.195 + 1.801X2 - 0.271X4 - 0.993X5$$
$$(0.465) \quad (0.122) \quad (0.459)$$

60%. Table 6 ANOVA was showing another, combinations which was remained left due to not multi co-linearity were taken as X1 (Maximum Temperature), X2(Minimum Temperature) and X10(Evaporation),which gave 60% value of R^2 towards the prediction of Mites population.

Since, Fcal > Ftab the null hypothesis was rejected and there was significant difference among the variables And R^2 *i.e.* coefficient of determination was 86%. Table 9 ANOVA was showing the weather variable combinations as X2 (Minimum Temperature), X4 (Rainfall) and X5 (Morning Relative Humidity) were

Table 9 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X4, X5.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	102.628	3	34.209	8.811	6.590	0.869
Residual	15.530	4	3.883			
Total	118.158	7				

on the basis of zero order correlation matrix the value of coefficient of determination (R^2) was found to be 75% showing the importance of Max temperature, Morning Relative Humidity and Wind Speed up to 75% towards prediction of Mites population.

Since, Fcal< Ftab the null hypothesis was accepted and there were no significant difference among the variables and R^2 *i.e.* coefficient of determination was

taken into consideration for predicting the Mites population on the basis of zero order correlation matrix .the value of coefficient of determination (R^2) was found to be 86% showing the importance of Minimum temperature, Rainfall and Morning relative humidity up to 86% towards prediction of Mites population.

Since, Fcal< Ftab the null hypothesis was accepted and there was no significant difference among the

Table 10 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X1, X2, X10).

Model	Coefficients	Std. Error	t-value
Constant	-14.738	11.902	-1.238
X1	-0.554	1.056	-0.524
X2	1.706	1.093	1.561
X10	8.832	5.821	1.517

The regression equation was obtained as follows:

$$\hat{Y}_i = -14.738 - 0.554X1 + 1.706X2 + 8.832X10$$
$$(1.056) \quad (1.093) \quad (5.821)$$

combinations which was remained left due to not multi co-linearity were taken as X1 (Maximum Temperature), X2 (Minimum Temperature) and X10(Evaporation), which gave 60% value of R^2 towards the prediction of Mites population.

Since, Fcal>Ftab the null hypothesis was rejected and there was significant difference among the variables. And R^2 *i.e.* coefficient of determination was 83%. There was critical difference of 7.683. Table 14 ANOVA was showing the weather variable combinations as X2 (Minimum Temperature), X3 (Sunshine) and X6 (Evening Relative Humidity) were taken into consideration for

Table 11 : Analysis of Variance of regression model of mean mites population of Garlic crop on X1, X2, X10.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	71.380	3	23.793	2.035	6.590	0.604
Residual	46.777	4	11.694			
Total	118.158	7				

Table 12 : Correlation coefficients among the weather variables at 1^{st} November Transplanting period.

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Y	1											
X1	.759*	1										
X2	0.236	0.448	1									
X3	0.403	.781*	-0.027	1								
X4	-0.420	-0.367	0.619	-0.626	1							
X5	-.767*	-0.666	0.090	-0.660	0.605	1						
X6	-0.593	-0.554	0.472	-.714*	.926**	0.702	1					
X7	-0.166	-0.253	-0.407	0.008	-0.397	0.220	-0.211	1				
X8	0.053	0.347	.953**	-0.057	0.644	0.304	0.542	-0.307	1			
X9	-0.109	0.055	.881**	-0.370	.798*	0.381	.780*	-0.427	.892**	1		
X10	.729*	.796*	-0.138	.877**	-.756*	-.886**	-.883**	-0.040	-0.255	-0.517	1	
X11	-0.263	-0.522	0.237	-0.644	0.694	0.174	.748*	-0.288	0.138	0.478	-0.573	1

**.Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

Table 13 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X3, X6).

Model	Coefficients	Std. Error	t-value
Constant	24.374	12.941	1.884
X2	3.112	0.916	3.398
X3	-2.287	1.251	-1.828
X6	-0.666	0.174	-3.828

The regression equation was obtained as follows:

$$\hat{Y}_i = 24.374 + 3.112X2 - 2.287X3 - 0.666\,X\,6\,(0.916)\,(1.251)\,(0.174)$$

variables. And R^2 *i.e.* Coefficient of determination was 60%. Table 11 ANOVA was showing another,

predicting the Mites population on the basis of zero order correlation matrix. The value of coefficient of determination (R^2) was found to be 83% showing the importance of Minimum Temperature, Sunshine and Evening Relative Humidity up to 83% towards prediction of Mites population.

Since, Fcal>Ftab the null hypothesis was rejected and there was significant difference among the variables and R^2 *i.e.* Coefficient of determination was 85%. There was critical difference of 7.257. Table 16 ANOVA was showing another, combinations, which was remained left due to not multi co-linearity were taken as X2 (Minimum Temperature), X6 (Evening Relative Humidity) and X11 (Rainy days), which gave 85% value of R2 towards the

Table 14 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X3, X6.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	229.342	3	76.447	6.671	6.590	0.833
Residual	45.838	4	11.459			
Total	275.180	7				

Table 15 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X6, X11).

Model	Coefficients	Std. Error	t-value
Constant	8.501	6.512	1.305
X2	2.583	0.763	3.384
X6	-0.640	0.149	-4.302
X11	5.058	2.459	2.057

The regression equation was obtained as follows:

$$\hat{Y}_i = 8.501{+}2.583X2{-}0.640X6{+}5.058X11\ (0.763)(0.149)(2.459)$$

prediction of Mites population.

Since, Fcal< Ftab the null hypothesis was accepted and there was no significant difference among the variables and R^2 *i.e.* Coefficient of determination was 69%. Table 19 ANOVA was showing the weather variable combinations as X2 (Minimum Temperature) and X6 (Evening Relative Humidity) were taken into consideration for predicting the Mites population on the basis of zero order correlation matrix. The value of coefficient of determination (R^2) was found to be 69% showing the importance of Minimum temperature and Evening Relative Humidity up to 69% towards prediction of Mites population.

Table 16 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X6, X11.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	234.281	3	78.094	7.638	6.590	0.851
Residual	40.899	4	10.225			
Total	275.180	7				

Table 17 : Correlation coefficients among the weather variables at 15th November Transplanting period.

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Y	1											
X1	.844**	1										
X2	0.302	0.448	1									
X3	0.489	.781*	-0.027	1								
X4	-0.483	-0.367	0.619	-0.626	1							
X5	-0.661	-0.666	0.090	-0.660	0.605	1						
X6	-0.608	-0.554	0.472	-.714*	.926**	0.702	1					
X7	-0.050	-0.253	-0.407	0.008	-0.397	0.220	-0.211	1				
X8	0.176	0.347	.953**	-0.057	0.644	0.304	0.542	-0.307	1			
X9	-0.037	0.055	.881**	-0.370	.798*	0.381	.780*	-0.427	.892**	1		
X10	.716*	.796*	-0.138	.877**	-.756*	-.886**	-.883**	-0.040	-0.255	-0.517	1	
X11	-0.459	-0.522	0.237	-0.644	0.694	0.174	.748*	-0.288	0.138	0.478	-0.573	1

**.Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

Table 18 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X6).

Model	Coefficients	Std. Error	t-value
Constant	3.884	7.843	0.495
X2	2.272	0.960	2.367
X6	-0.413	0.128	-3.231

The regression equation was obtained as follows:

$$\hat{Y}_i = 3.884{+}2.272X2{-}0.413X6$$
$$(0.960)\qquad(0.128)$$

Since, Fcal< Ftab the null hypothesis was accepted and there was no significant difference among the variables. And R^2 *i.e.* coefficient of determination was 66%. Table 21 ANOVA was showing another, combinations, which was remained left due to not multi co-linearity were taken as X3 (Sunshine), X6 (Evening Relative Humidity) and X8 (Morning Vapour Pressure) which gave 66% value of R^2 towards the prediction of

Table 19 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X6.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	191.030	2	95.515	5.675	5.79	0.694
Residual	84.150	5	16.830			
Total	275.180	7				

Table 20 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X3, X6, X8).

Effect	Coefficients	Std. error	t-value
Constant	11.934	18.708	0.638
X3	-2.155	1.854	-1.162
X6	-0.657	0.270	-2.430
X8	4.334	2.250	1.926

The regression equation was obtained as follows:

$$\hat{Y}_i = 11.934\text{-}2.155X3\text{-}0.657X6\text{+}4.334X8$$
$$(1.854) \quad (0.270) \quad (2.250)$$

Mites population.

Since, Fcal< Ftab the null hypothesis was accepted and there was no significant difference among the variables. And R^2 *i.e.* Coefficient of determination was 66%. Table 24 ANOVA was showing the weather variable combinations as X2 (Minimum Temperature), X10 (Evaporation) and X11 (Rainy days) were taken into consideration for predicting the Mites population on the basis of zero order correlation matrix. The value of coefficient of determination (R^2) was found to be 66% showing the importance of Minimum temperature, Evaporation and Rainy days up to 99% towards prediction of Mites population.

Table 21 : Analysis of Variance of regression model of mean mites population of Garlic crop on X3, X6, X8.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	182.743	3	60.914	2.636	6.59	0.664
Residual	92.437	4	23.109			
Total	275.180	7				

Table 22 : Correlation coefficients among the weather variables at 1st December Transplanting period.

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Y	1											
X1	.810*	1										
X2	0.264	0.448	1									
X3	0.442	.781*	-0.027	1								
X4	-0.476	-0.367	0.619	-0.626	1							
X5	-0.668	-0.666	0.090	-0.660	0.605	1						
X6	-0.626	-0.554	0.472	-.714*	.926**	0.702	1					
X7	-0.057	-0.253	-0.407	0.008	-0.397	0.220	-0.211	1				
X8	0.123	0.347	.953**	-0.057	0.644	0.304	0.542	-0.307	1			
X9	-0.084	0.055	.881**	-0.370	.798*	0.381	.780*	-0.427	.892**	1		
X10	.710*	.796*	-0.138	.877**	-.756*	-.886**	-.883**	-0.040	-0.255	-0.517	1	
X11	-0.436	-0.522	0.237	-0.644	0.694	0.174	.748*	-0.288	0.138	0.478	-0.573	1

**.Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

Table 23 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X10, X11).

Effect	Coefficients	Std. error	t-value
Constant	-21.306	12.034	-1.770
X2	1.090	1.023	1.065
X10	7.993	3.288	2.431
X11	1.289	2.998	0.430

The regression equation was obtained as follows:

$$\hat{Y}_i = \text{-}21.306\text{+}1.090X2\text{+}7.993X10\text{+}1.289X11$$
$$(1.023) \quad (3.288) \quad (2.998)$$

of Mites population.

Since, Fcal< Ftab the null hypothesis was accepted and there was no significant difference among the variables. And R^2 i.e. coefficient of determination was 69%. Table 26 ANOVA was showing another, combinations which was remained left due to not multi co-linearity were taken as X2 (Minimum temperature) and X6 (Evening Relative Humidity), which gave 69% value of R^2 towards the prediction of Mites population.

Table 24 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X10, X11.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	182.283	3	60.761	2.616	6.590	0.662
Residual	92.897	4	23.224			
Total	275.180	7				

Table 25 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X6).

Effect	Coefficients	Std. error	t-value
Constant	3.884	7.843	0.495
X2	2.272	0.960	2.367
X6	-0.413	0.128	-3.231

The regression equation was obtained as follows:

$$\hat{Y}_i = 3.884 + 2.272X2 – 0.413X6$$
$$(0.960) \qquad (0.128)$$

Since, Fcal< Ftab the null hypothesis was accepted and there was no significant difference among the variables. And R^2 *i.e.* coefficient of determination was 66%. Table 29 ANOVA was showing the weather variable combinations as X2 (Minimum Temperature), X10 (Evaporation) and X11 (Rainy days) taken into consideration for predicting the Mites population on the basis of zero order correlation matrix. The value of coefficient of determination (R^2) was found to be 66% showing the importance of Minimum temperature, Evaporation and Rainy days up to 66% towards prediction of Mites population.

Table 26 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X6.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	191.030	2	95.515	5.675	5.790	0.694
Residual	84.150	5	16.830			
Total	275.180	7				

Table 27 : Correlation coefficients among the weather variables at 15th December Transplanting period.

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Y	1											
X1	.829*	1										
X2	0.304	0.448	1									
X3	0.466	.781*	-0.027	1								
X4	-0.482	-0.367	0.619	-0.626	1							
X5	-0.642	-0.666	0.090	-0.660	0.605	1						
X6	-0.593	-0.554	0.472	-.714*	.926**	0.702	1					
X7	-0.031	-0.253	-0.407	0.008	-0.397	0.220	-0.211	1				
X8	0.181	0.347	.953**	-0.057	0.644	0.304	0.542	-0.307	1			
X9	-0.022	0.055	.881**	-0.370	.798*	0.381	.780*	-0.427	.892**	1		
X10	0.692	.796*	-0.138	.877**	-.756*	-.886**	-.883**	-0.040	-0.255	-0.517	1	
X11	-0.453	-0.522	0.237	-0.644	0.694	0.174	.748*	-0.288	0.138	0.478	-0.573	1

**.Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

Table 28 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X10, X11).

Model	Coefficients	Std.Error	t-value
Constant	-11.444	6.896	-1.659
X2	0.862	0.586	1.469
X10	3.435	1.884	1.823
X11	-0.896	1.718	-0.522

The regression equation was obtained as follows:

$$\hat{Y}_i = -11.444 + 0.862X2 + 3.435X10 – 0.896X11$$
$$(0.586) \qquad (1.884) \qquad (1.718)$$

Since, Fcal>Ftab the null hypothesis was rejected and there was significant difference among the variables. And R^2 *i.e.* coefficient of determination was 79%. There was Critical difference of 5.009. Table 31 ANOVA was showing another, combinations which was remained left due to not multi co-linearity were taken as X2 (Minimum temperature) and X6 (Evening Relative Humidity), which gave 79% value of R^2 towards the prediction of Mites population.

Table 29 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X10, X11.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	60.373	3	20.124	2.639	6.590	0.664
Residual	30.507	4	7.627			
Total	90.880	7				

Table 30 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X6).

Effect	Coefficients	Std. error	t-value
Constant	0.770	3.727	0.207
X2	1.478	0.456	3.241
X6	-0.248	0.061	-4.086

The regression equation was obtained as follows:

$$\hat{Y}_i = 0.770 + 1.478X2 - 0.248X6$$

(0.456) (0.061)

up to 75% towards prediction of Mites population.

Since, Fcal<Ftab the null hypothesis was accepted and there was no significant difference among the variables. And R^2 *i.e.* coefficient of determination was 74%. Table 36 ANOVA was showing another, combinations which was remained left due to not multi co-linearity were taken as X4 (Sunshine), X6 (Evening Relative Humidity) and X10 (Evaporation), which gave 74% value of R^2 towards the prediction of Mites population.

Table 31 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X6.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	71.880	2	35.940	9.458	5.790	0.791
Residual	18.999	5	3.800			
Total	90.880	7				

Table 32 : Correlation coefficients among the weather variables at 1st January Transplanting date.

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Y	1											
X1	.891**	1										
X2	.777*	.800*	1									
X3	0.607	.805*	0.435	1								
X4	-0.410	-0.544	-0.035	-0.670	1							
X5	-.769*	-.858**	-.772*	-0.640	0.119	1						
X6	-0.618	-.777*	-0.287	-.724*	.819*	0.569	1					
X7	-0.704	-0.571	-0.474	-0.312	-0.017	.780*	0.398	1				
X8	.750*	.730*	.912**	0.468	-0.181	-0.553	-0.213	-0.230	1			
X9	0.101	0.001	0.491	-0.223	0.470	-0.035	0.577	0.039	0.583	1		
X10	.827*	.941**	0.623	.848**	-0.559	-.870**	-.862**	-0.622	0.513	-0.284	1	
X11	-0.400	-0.528	-0.022	-0.629	.998**	0.101	.819*	-0.017	-0.163	0.471	-0.538	1

**.Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

Since, Fcal< Ftab the null hypothesis was accepted and there was no significant difference among the variables. And R^2 *i.e.* coefficient of determination was 75%. Table 34 ANOVA was showing the weather variable combinations as X7 (Wind Speed), X10 (Evaporation) and X11(Rainy days) were taken into consideration for predicting the Mites population on the basis of zero order correlation matrix. The value of coefficient of determination (R^2) was found to be 75% showing the importance of Wind Speed, Evaporation and Rainy days

Since, Fcal< Ftab the null hypothesis was accepted and there was no significant difference among the variables. And R^2 *i.e.* coefficient of determination was 75%. Table 39 ANOVA was showing the weather variable combinations as X6 (Evening Relative Humidity), X8 (Morning Vapour Pressure) and X11(Rainy days) were taken into consideration for predicting the Mites population on the basis of zero order correlation matrix The value of coefficient of determination (R^2) was found to be 75% showing the importance of Evening Relative Humidity,

Table 33 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X7, X10, X11).

Model	Coefficients	Std.Error	t-value
Constant	6.832	15.060	0.454
X7	-2.982	2.937	-1.016
X10	2.521	2.157	1.169
X11	-0.559	1.550	-0.361

The regression equation was obtained as follows:

$$\hat{Y}_i = 6.832\text{-}2.982X7+2.521X10–0.559X11$$

(2.937) (2.157) (1.550)

Table 34 : Analysis of Variance of regression model of mean mites population of Garlic crop on X7, X10, X11.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	57.152	3	19.051	4.022	6.590	0.751
Residual	18.944	4	4.736			
Total	76.097	7				

Table 35 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X4, X6, X10).

Model	Coefficients	Std.Error	t-value
Constant	-21.534	15.412	-1.397
X4	-0.193	0.336	-0.576
X6	0.232	0.257	0.904
X10	6.362	2.811	2.263

The regression equation was obtained as follows:

$$\hat{Y}_i = \text{-}21.534\text{-}0.193X4+2.232X6+6.362X10$$

(0.336) (0.257) (2.811)

Table 36 : Analysis of Variance of regression model of mean mites population of Garlic crop on X4, X6, X10.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	56.385	3	18.795	3.814	6.590	0.741
Residual	19.711	4	4.928			
Total	76.097	7				

Table 37 : Correlation coefficients among the weather variables at 15th January Transplanting Period.

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Y	1											
X1	.778*	1										
X2	0.571	.800*	1									
X3	0.530	.805*	0.435	1								
X4	-0.306	-0.544	-0.035	-0.670	1							
X5	-.813*	-.858**	-.772*	-0.640	0.119	1						
X6	-0.688	-.777*	-0.287	-.724*	.819*	0.569	1					
X7	-.843**	-0.571	-0.474	-0.312	-0.017	.780*	0.398	1				
X8	0.415	.730*	.912**	0.468	-0.181	-0.553	-0.213	-0.230	1			
X9	-0.252	0.001	0.491	-0.223	0.470	-0.035	0.577	0.039	0.583	1		
X10	.859**	.941**	0.623	.848**	-0.559	-.870**	-.862**	-0.622	0.513	-0.284	1	
X11	-0.300	-0.528	-0.022	-0.629	.998**	0.101	.819*	-0.017	-0.163	0.471	-0.538	1

**.Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

Table 38 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X6, X8, X11).

Effect	Coefficients	Std.Error	t-value
Constant	3.310	7.595	0.436
X6	-0.263	0.090	-2.939
X8	0.798	0.746	1.071
X11	2.362	1.285	1.838

The regression equation was obtained as follows:

$$\hat{Y}_i = 3.310 - 0.263X6 + 0.798X8 + 2.362X11$$

(0.090) (0.746) (1.285)

Table 39 : Analysis of Variance of regression model of mean mites population of Garlic crop on X6, X8, X11.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	26.007	3	8.669	4.118	6.590	0.755
Residual	8.421	4	2.105			
Total	34.428	7				

Table 40 : Regression coefficients of the model of mites population with meteorological parameters in Garlic crop (X2, X9).

Effect	Coefficients	Std. Error	t-value
Constant	-1.961	3.610	-0.543
X2	1.347	0.414	3.253
X9	-1.005	0.403	-2.493

The regression equation was obtained as follows:

$$\hat{Y}_i = 1.961 + 1.347X2 - 1.005X9$$

(0.414) (0.403)

Table 41 : Analysis of Variance of regression model of mean mites population of Garlic crop on X2, X9.

Source	Sum of Squares	DF	Mean Square	F-cal	F-tab	R Square
Regression	24.084	2	12.042	5.821	5.790	0.700
Residual	10.344	5	2.069			
Total	34.428	7				

Morning Vapour Pressure and Rainy days up to 75% towards prediction of Mites population.

Since, Fcal>Ftab the null hypothesis was rejected and there was significant difference among the variables. And R^2 *i.e.* coefficient of determination was 70%. There was Critical difference of 3.696. Table 41ANOVA was showing another, combinations, which was remained left due to not multi co-linearity were taken as X2 (Minimum Temperature) and X9 (Evening Vapor Pressure), which gave 70% value of R^2 towards the prediction of Mites population.

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