Warning System for European Redmite Using Beta Model

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Abstract- European red mite is a serious problem of apple in Himachal Pradesh .At present more than 80 % orchards have been found infested with European red mite. It sucks cell sap from leaves which resulted into poor quality of fruits. Present studies were undertaken to see the effect of environmental factors e.g. temperature and relative humidity on the buildup of mite population in the apple trees at RHRS, Mashobra. The predicted optimum temperature and relative humidity was calculated by using Beta model is 21.45°C and <85% respectively. Since from the last few years regional observation and experimental database on prediction of pest attack on crop about infection index correspondence to above mentioned environmental parameters was prepared using software Microsoft EXCEL. After that from collected data a mathematical prediction model was developed using the MATLAB as software tool. A generalized form of Beta model was provided to best fit in the data. The value of R^2 we observed for eggs and motiles was 82.8 and 84.5 respectively.

Index Terms- European red mite, Beta model, Protonymph, Deutonymph.

I. Introduction

The European red mite (*Panonychus ulmi* Koch) was first recorded in Oregon in 1911 and since then it became common in the United States and Canada. In India it was reported for the first time in 1974 from north western Himalayan region of Jammu and Kashmir, Himachal Pradesh on apple, peach, apricot and quince (Prasad, 1974). In Himachal Pradesh it was again observed in 1991 but appeared in epidemic form since 1995 and at present more than 72% orchard have been found infested with European red mite (Bhardwaj and Bhardwaj, 2005). The European Red Mite undergoes three stages between egg hatching and adulthood. They are known as larva, protonymph and deutonymph. Adults as well as nymphs suck cell sap from leaves which turn dull green and finally turn bronze in colour. Heavily infested plants yield poor quality fruit in terms of colour and size which did not fetch good price in the market. Mite multiplication dependent on weather parameters like temperature, relative humidity and rainfall (Huffaker ,et.al. 1969).

In the winter season the European red mite overwinters in the form of an egg stage. Eggs are usually laid on the lower side of the small branches and twigs. They are often found around the crevices of forks of two branches and other rough areas. Hatching of eggs is closely related to the bud development and also it occurs first when buds are in the tight cluster stage. Also the first summer egg can be found at petal fall or latest by fruit set. The development is most rapid in summer months along with high humidity as compared to spring and fall. The first generation generally requires 3 weeks to develop and on the other hand it takes 10 to 12 days for the summer generation to develop. European red mite population is affected by the environmental factors like temperature, relative humidity, rainfall, etc. Keeping in view the severity of the pes,t efforts have been made to develop a warning system so that control measures can be adopted well in time. From collected data on no. of eggs/motiles per leaf a mathematical prediction model was developed using the MATLAB as software tool. A generalized form of Beta model was provided to best fit in the data. The value of R^2 we observed for eggs and motiles was 82.8 and 84.5 respectively.

II. Materials and Methods

Experiment was conducted to study the effect of environmental factors on mite population on 15 to 20 years old apple trees cv. Oregon spur in the orchard of Regional Horticultural Research Station, Dr Y.S. Parmar University of Horticulture and Forestry at Mashobra (21˚1N,71˚1E; 2286m amsl), Shimla. A weekly fifty leaves were collected randomly from each tree. Population of mite is determined by counting the number of motiles and eggs on dorsal as well as ventral surface of leaves under binocular microscope. Meteorological data on the temperature, humidity and rainfall were recorded on weekly intervals from the observatory at RHRS, Mashobra and their weekly averages were calculated.

III. Model Development and Data Analysis

Regression analysis was used in order to (i) determine if temperature, relative humidity and their interaction significantly affected the population of the mite in the form of the eggs and motiles and (ii) also in order to determine the functional form of the relationship between the number of eggs/leaves, disease severity and the controlled environmental variables.

The model which was evaluated by using the data is a generalized form of the Analytical Beta model. The Beta model can be written in the form:

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$Y = \alpha t^{\beta}(1-t)^{\gamma}H^{\delta}$ (eq. 1)

in which Y is defined as severity index and H is defined as the relative humidity, β, δ are the unknown parameters estimated from data and t is defined as follow:-

$t = (T-T_{min})/(T_{max}-T_{min})$ (eq. 2)

Equation 1 can be linearized to:

$\log(Y) = \log(\alpha) + \beta\log(t) + \gamma\log(1-t) + \delta\log(W)$ (eq. 3)

The models were evaluated during (i) regression coefficient (r^2), (ii) correlation coefficient (r), (iii) mean square error (MSR) and (iv) root mean square error (RMSE). The parameters of above equation were estimated from leaf infestation. The model include terms like temperature, wetness duration, and their product and also estimated parameters would be significantly greater than 0 therefore, these two environmental variables and their interaction affected disease intensity.

IV. RESULTS AND DISCUSSION

The temperature and relative humidity has a major effect on the population of European red mite. As we can see in the figure that by increasing the temperature from 13 - 21.45°C and the relative humidity ranges from 55-85% or above increases the population of both motile and eggs. The experimental data of the year (2002 and 2003) were considered in this paper. Similarly there was an increase in the population of the motiles and eggs when the humidity ranges from 25 - 85.5% or above.

In Figure 1 and 2, the graph determines the effects on the population of the motiles and eggs. As the temperature increases from 9.45°C - 21.45°C there was an increase in the number of motiles and eggs respectively. As it is known that 21.45°C was considered to be an optimum temperature so, when the temperature increases from the optimum temperature then there was a decrease in the population of the motiles and eggs. In Figure 3 and 4, it determines the effect of the humidity on the population of the eggs and motiles. When the humidity increases from 25% to 85% there was an increase in the population of mite.

According to the graph the population of the red mite can be easily determined whether it is in the form of the motiles or eggs. By using the experimental data the value of unknown parameters in the generalized beta model was calculated. As it was discussed earlier in equation the model depends on the two environmental parameters that is temperature and humidity and the value of unknown parameters of the beta model depends on these two environmental parameters. Their value will be greater than 0 therefore disease severity is affected by the interaction between these two environmental parameters. For generalized Beta model T_{min} and T_{max} should be known so as to determine the parameters of the Beta model. Using the data collected through experiments T_{min} and T_{max} was 9.45ºC and 21.45ºC respectively. For model development we used T_{min} and T_{max} as 9.45 ± 0.1ºC and 21.45 ± 0.1ºC respectively. The collected data is then used to find value of various unknown parameters whose value will be constant to form a standard equation for European red mite. As we can see that in table1 and table 2 shows the value of various parameters used in the generalized Beta model for various replications along with the coefficient of determination for both the motiles and the eggs respectively.

According to Table. 1 the value of the R^2 for replication one is 0.828 and for the second replication the value is 0.801. In Table 2, it indicates that the value R^2 population of motile i.e. for replication one and for replication two is 0.845 and 0.781 respectively. As we know that for model fitness we considered the value of R^2 which is more close to one. So we can say that the parameter value for replication one in both the case of motiles and eggs gives more accurate results as compared to the replication two in both the cases respectively. In Figure 5 and 6, the relationship between the observed eggs and predicted eggs is shown in the form of a graph. The coefficient of determination (R^2) between observed values and predicted values were determined as 0.845 for motiles and 0.828 for eggs. The generalized form of Analytical Beta model (equation) was found to best fit the data in order to determine the population of motiles and eggs.

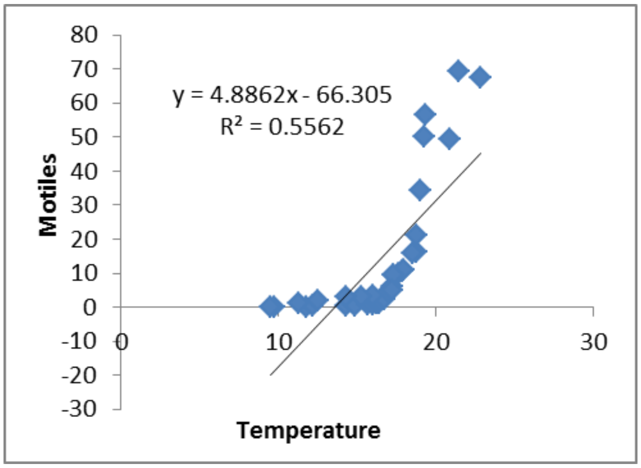

Fig1.

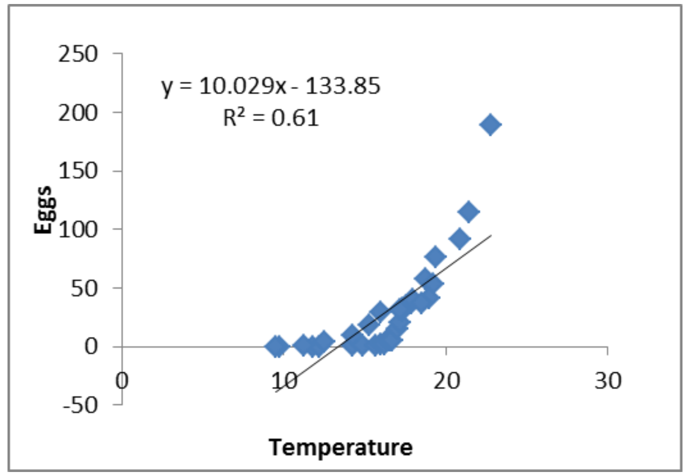

Fig2.

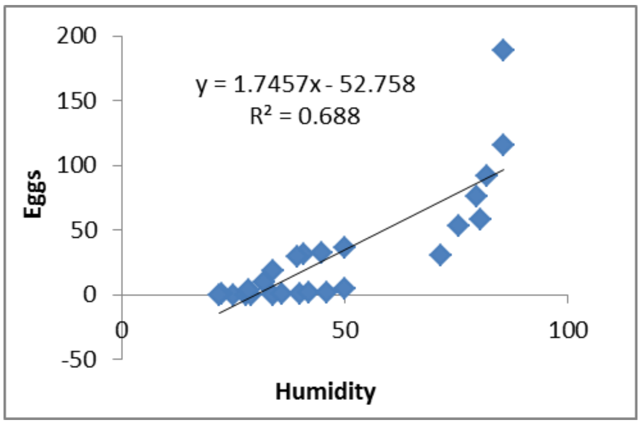

Fig3.

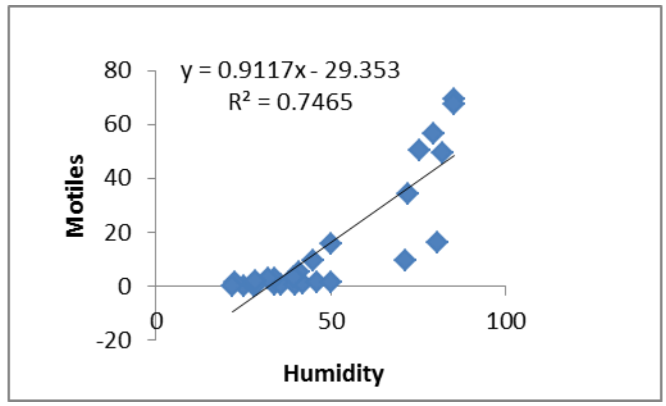

Fig4.

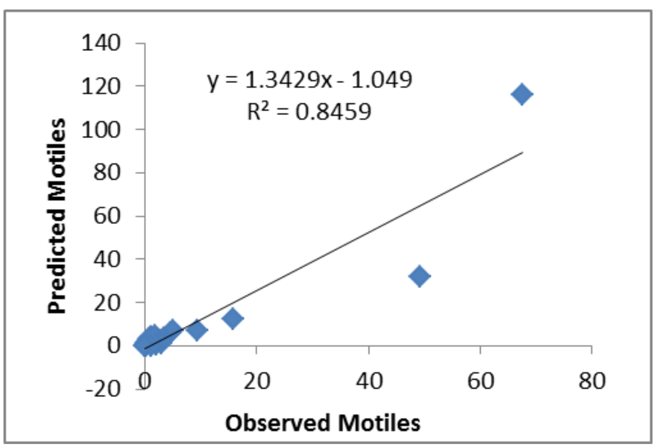

Fig5.

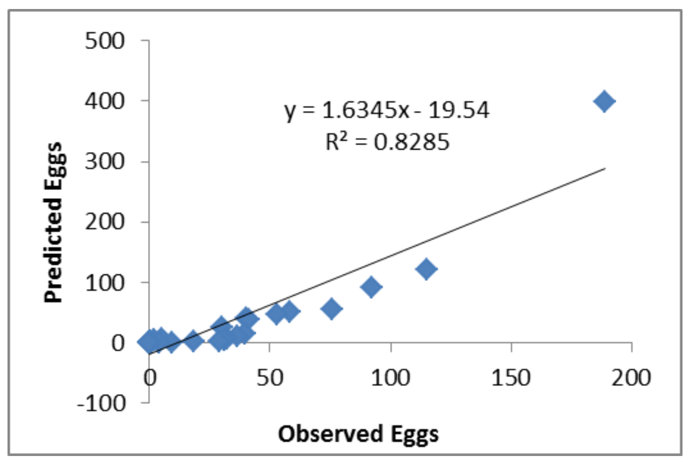

Fig6.

Fig 1 & 2. Shows the relationship between observed and predicted motiles and eggs based on the generalized Beta model, with parameters estimated in Tables 1 and 2. Coefficient of determination is given as R^2 in the graphs.

Fig 3&4. Shows the increase in the population of the motiles when there is an increase in the temperature and humidity. Coefficient of determination is given as R^2 in the graphs.

Fig 5&6. In this the relationship between the temperature and humidity with the increase in the population of eggs are shown as the temperature and humidity increases. Coefficient of determination is given as R^2 in the graphs.

Table 1. Estimated parameters from the generalized Beta model for temperature (T) and wetness duration (W) effects on the population of the European red mite in the form of Eggs.

Estimated parameters[a] for Eggs					
	α′	β	γ	δ	R^2
Replication 1	2.51	0.0994	-0.7916	4.7005	0.828
Replication 2	-8.9614	1.4717	-0.3091	2.9733	0.801

Table 2. Estimated parameters from the generalized Beta model for temperature (T) and wetness duration (W) effect on the population of the European red mite in the form of motiles.

Estimated parameters[a] for Motiles					
	α′	β	γ	δ	R^2
Replication 1	3.736	3.436	-0.2117	-0.342	0.845
Replication 2	-8.9614	1.4717	-0.3091	2.9733	0.781

NOTE: In both the above tables 1 & 2 estimated parameters from the generalized Beta Model: α′ corresponds to the log-transformed α, β and γ correspond to temperature effect, and δ corresponds to wetness duration.

V. CONCLUSION

According to literature survey has been done and we concluded that until now no such warning system has been developed for European Red mite using Beta model. This model gives the best fitness between observed value and predicted value. The high value of correlation coefficient and coefficient of determination denotes that this model approaches the real value of observation and gives the best approximation. For the development of warning system, it gives the suitable solution and a system or machine can be easily trained through particular software using this model. For the simulation and model development, the software approach was used and programming was done in MATLAB.

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