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Influence of Biotic and Abiotic Factors on Tritrophic Relations of Mulberry, Mealy Bug, *Maconellicoccus Hirsutus* (Green) and its Entomophages

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Abstract

The biotic and the abiotic factors influencing the tritrophic relations between the mulberry, the mealy bug and its entomophages were studied to enhance the efficacy of integrated pest management technique against the pest. The biotic and the abiotic factors heavily influenced the tritrophic relations. The temperature showed positive correlation with the mealy bug infestation and its population while the relative humidity, rainfall and rainy days showed a negative correlation. The seasonal activity of the entomophages coincided with the activity of the mealy bugs. The entomophages population is significantly positively correlated with temperature and negatively correlated with rainfall, rainy days and humidity. The major biotic factors affecting the relations are the presence of four types of ants. The average number of mealy bug population was comparatively higher in ant attended colonies (61.22) than unattended ones (49.22). The population of predatory fauna decreased significantly (1.0) on ants association compared to the mealy bug infested shoots free from the ants (4.78) which indicates the deterring potentiality of the attendant ants on predators. Results revealed that the abiotic factors should be considered before the release of bio control agents, the movement of ants should be restricted and generalized predator should be encouraged.

Keywords: Biotic and abiotic factors, entomophages, *Maconellicoccus hirsutus,* mulberry, tritrophic relations.

Introduction

Mulberry is attacked by more than 300 species of insects of which the pink mealy bug, *Maconellicoccus hirsutus* (Green) (Homoptera: Pseudococcidae) which causes tukra is found to be more destructive[1]. The tritrophic relations among mulberry, mealy bug, and entomophages had to be integrated to manage the pests effectively. Although there is substantial information on the ways in which plants influence the biological control agents, often we still lack an appropriate ecological context within which to interpret that information. The plants may directly influence the behaviour of their herbivores and entomophages, ecological interactions between two species are often indirectly mediated by a third species[2]. The combinations of environmental factors both biotic and abiotic determine the distribution and abundance of species[3]. The effects of temperature changes are seldom exerted alone but usually act in combination with one or more other physical factors[4]. The tritrophic relations among mulberry, mealy bug and its entomophages varied significally with varieties and seasons[5]. In the present study, tritrophic relations of mealy bug infestation in mulberry, mealy bug population, and entomophages abundance were observed. The influence of temperature, relative humidity, rainfall, and number of rainy days on the tritrophic relations were studied and correlated.

Material and Methods

The study was conducted on the mulberry garden at, Nagercoil, Tamilnadu, South India, situated between $77^0$05' and $77^0$26' of the eastern longitudes and $8^0$03' and $8^0$35' of the northern latitudes. The mulberry plants were pruned and all the recommended cultural practices were followed and kept free from pesticides sprays during the period of study. The observations were made at 15 days interval for a period of two years. The mealy bug infested plants with live mealy bugs were counted. In the affected plants the individual branches were counted separately for infestation, number of mealy bugs and entomophages present in the infested plants were also recorded. At each observation the parasitized mealy bug mummies, if any were collected and brought to the laboratory for emergence. Other insects found in association with mealy bug were also accounted. The percentage of infested plants was worked out by dividing total no. of infested plants by total no. of plants in the garden X 100. The mealy bug population in the plants was calculated by dividing total number of insects counted by total number of plants assessed. Entomophages population in an infested plant was calculated by dividing total number of individual Predators /Parasitoids by total number of plants assessed. The data for individual natural enemy were assessed and added to find the entomophages population. Insects were assessed very carefully without any damage or change to the ecosystem. Data on weather parameters such as maximum temperature, minimum temperature, relative humidity, rainfall and rainy days were collected during the period of study and correlated with tritrophic levels. Multiple

regression equations were formulated to predict the occurrence of infestation, mealy bug and entomophages.

Results and Discussion

The mealy bug was seen throughout the year except in November month. (figure-1). The population ranged from 1.0 to 15.8 number /plant. The highest infestation was recorded in February II fortnight affecting 37.8 per cent of branches of 59.5 per cent of plants. The mealy bug infestation ranged from 2.3 to 59.5 per cent. The numbers of entomophages per single infested plant ranged from 0.1 to 1.7. The entomophages observed were the lady bird predators, *Nephus regularis* (Sicard) (Coccinellidae; Coleoptera), spiders, reduviids, preying mantis and the hymenopterous parasitoid (*Leptomastix dactylopii*). The grubs and adults of *N. regularis* were noticed in the infestations. The parasitized mummies were recorded during March, June, and September. Preying mantises the generalized predators were noted in four different months and reduviids were noted during June only.

Impact of biotic factors on mealy bug infestation and population: The maximum temperature ranged from 32^0 to 40^0C. The temperature was very higher ranging from 37^0C to 40^0C for 10 months and *M. hirsutus* infestation and population were non significantly positive correlated (table-1 and 2). The minimum temperature ranged from 21^0C to 25^0C. The minimum temperature had a significant positive correlation with the infestation and the correlation coefficient was 0.50. Increase in temperature increased the mealy bug population and infestation. When high temperature prolonged for longer period mealy bug infestation was reduced. Each species of insect have certain temperature limits beyond which they were killed because arthropods are cold blooded[6].

The average relative humidity ranged from 60 per cent to 89 per cent. Relative humidity was negatively correlated with mealy bug infestation and population with the correlation coefficients of –0.238. The rainfall ranged from 9.7 mm to 99.2 mm with the total shower of 608.9mm. There was a sudden reduction in mealy bug infestation after heavy rainfall. Distribution of rainfall over the year is an extremely important limiting factor for organisms[7]. Rainfall and rainy days played a major role in determining the mealy bug population and mealy bug infestation. 99.2mm of rain for six days in May first fortnight reduced the mealy bug infestation from 50.2% to 7.2%. The rainfall was negatively correlated with mealy bug infestation and population with the correlation coefficient of –0.112. The heavy rainfall washes away the mealy bug. When the number of rainy days increased the mealy bug infestation in the corresponding fortnight reduced.

Correlation of mealy bug infestation, mealy bug population and entomophages: The population of mealy bug and infestation showed a highly significant correlation with entomophages population with the correlation coefficient of 0.690 and 0.802. The population dynamics of arthropod predator–prey system are often determined by differences in weather condition[9]. The seasonal activity of the entomophages coincided with the activity of the mealy bugs. In the study period *Nephus regularis* was the dominant coccinellid. *Nephus sp* as potential predator[10]. Spiders were seen throughout the study period. The predatory spiders present in the mulberry garden were very potential in controlling the pests[11]. The generalists predators are more important than coccinellids as they are active early in the year and nip the potential pest out breaks in the bud.

Table-1
Correlation of mealy bug infestation with other biotic and abiotic factors

Factors	Correlation Coefficient	r^2	Regression Equation	T value
Branches affected (%)	0.890	0.7935	y = 0.5181x + 2.7882	9.186315**
Maximum temperature (^{0}c)	0.002	-	y = 0.0003x + 37.16	0.009381
Relative humidity (%)	-0.238	0.1086	y = -0.146x + 80.715	-1.18237
Rainfall (mm)	-0.112	0.0306	y = -0.2396x + 1.227	-0.53355
Rainy days (Nos.)	-0.215	0.0461	y = -0.0299x + .3563	-1.03252

Table-2
Correlation of mealy bug population with other biotic and abiotic factors

Factors	Correlation Coefficient	r^2	Regression Equation	T value
Plants affected (%)	0.896	0.8023	y = 3.9342x - 0.0608	9.451832**
Natural enemies (Nos.)	0.690	0.4766	y = 0.0882x + 0.201	4.47346**
Maximum temperature (^{0}C)	0.058	0.0035	y = 0.0249x + 37.012	0.272521
Relative Humidity (%)	-0.238	0.0568	y = -0.4638x + 0.034	-1.14944
Rainfall (mm)	-0.112	0.0126	y = -0.6741x +29.571	-0.52867
Rainy days (No.s.)	-0.118	0.0139	y = -0.0722x +3.0744	-0.55736

Correlation of entomophages population with abiotic factors: The activity of entomophages was nonsignificantly positively correlated with temperature (table-3). The entomophages population was negatively correlated with relative humidity, rainfall and with rainy days. The results clearly indicate that the abiotic factors should be considered before the release of entomophages to manage mealy bug menance.

Influence of Ants on Tritrophic relations: Ants were seen in association with mealy bugs' colonies, attending mealy bugs in all stages including eggs, nymphs and adults. Four ant species *viz. Monomorium indicum*, *Solenopsis geminata*, *Tapinoma sessile* and *Camponotus compressus* were found to have association with the pink mealy bug in mulberry garden. The average mealy bug population was comparatively higher in ant attended colonies (61.22) than unattended one (49.22) (figure-2). The population of predatory fauna was decreased significantly (1.0) on ants association compared to the mealy bug infested shoots free from the ants (4.78) which indicates the deterring potentiality of the attendant ants on predators (figure-3). Beneficial interaction existed between the mealy bug and ants. Destruction of the predominant *M. indicum* colonies in mulberry ecosystem could help to increase the field activities of predatory fauna against *M. hirsutus*.

Multiple regression equations: The multiple regression equation fitted with weather parameters to predict the mealy bug infestation

$Y= -318.069 +2.382X_1 + 12.072X_2^{**} - 0.362X_3 + 0.028X_4 + 0.124X_5$

Where: X_1 is maximum temperature, X_2 is minimum temperature, X_3 is relative humidity X_4 is rainfall and X_5 is number of rainy days. The multiple regression equation fitted with weather parameters to predict the mealy bug population is,

$Y= -72.045 + 0.599X_1 + 2.613X_2^{*} - 0.008X_3 - 0.008X_4 + 2.52X_5$

The multiple regression equation fitted with weather parameters to predict the entomophages population is:

$Y= -8.879 + 0.076X_1 + 0.339X_2^{*} - 0.016X_3 - 0.011X_4 + 0.160X_5$

These regression equations can be utilized to predict the infestation and populations.

Table-3
Correlation of natural enemies with abiotic factors

Factors	r	r^2	Regression Equation	*T value*
Max. temperature (^{0}C)	0.041	0.0017	y = 0.1374x + 37.064	0.192471
Relative humidity (%)	-0.216	0.0468	y = -3.2952x + 79.617	-1.0377
Rainfall (mm)	-0.109	0.0119	y = -5.1365x + 29.225	-0.51432
Rainy days (No.s)	0.029	0.0008	y = 0.1374x + 2.5219	0.136076

** - Highly significant. * - Significant.

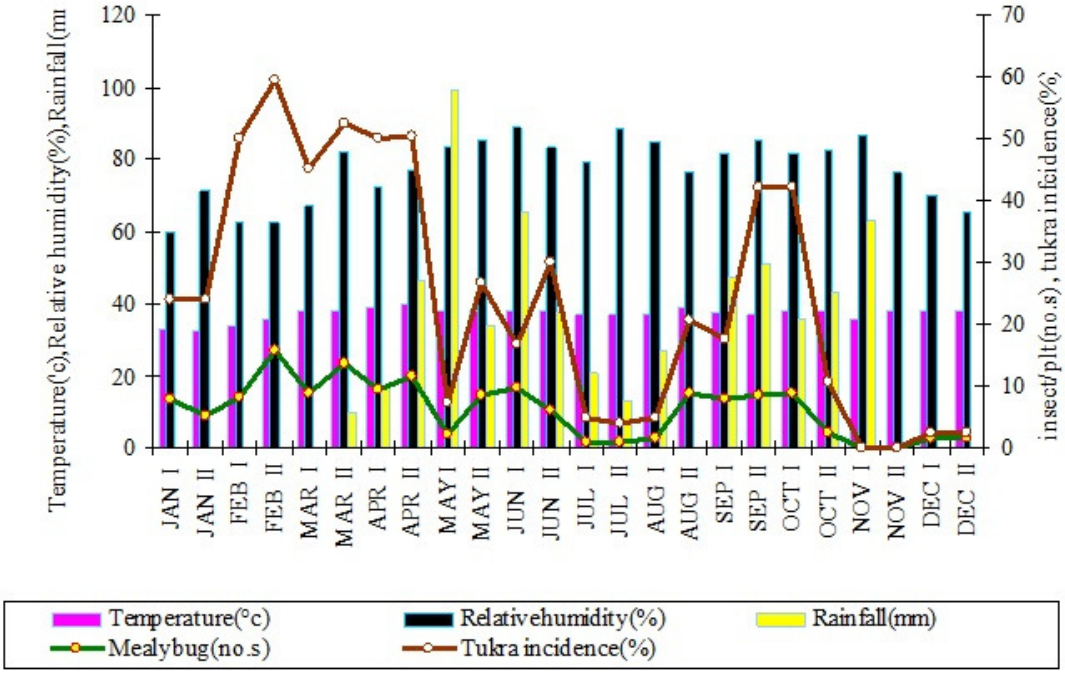

Figure-1
Influence of Abiotic Factors on Mealybug Population and Tukra Incidence

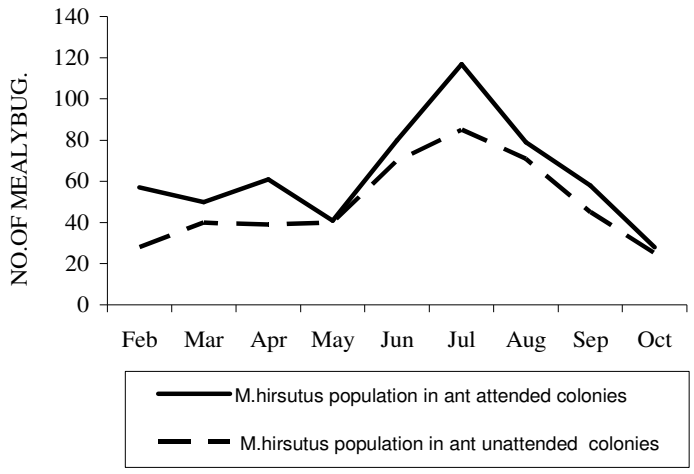

Figure-2
The Mealybug Population In Mulberry Garden Attended and Unattended by Ant

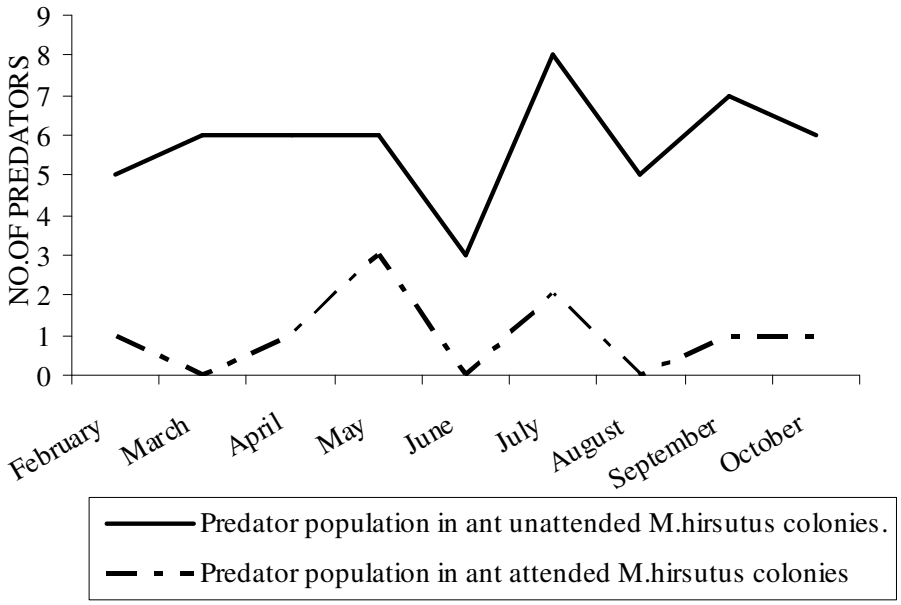

Figure-3
Predator Population in the Mealybug Colonies Attended and Unattended by Ant

Conclusion

It is concluded that the population dynamics of mealy bug, its infestation and entomophages were positively correlated with the temperature but affected when the temperature prolonged above 39±1°C and below 22^0C. The tritrophic members were negatively correlated with relative humidity, rainfall and with rainy days. The entomophages showed a highly density dependent relationship with the pest. Hence the abiotic factors should be considered before the release of bio control agents, the movement of ants should be restricted and generalized predator should be encouraged.

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