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Seasonal incidence of Cassava mealybug *Phenacoccus manihoti* (Matile-Ferrero) on Cassava *Manihot esculenta*

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ABSTRACT: The influence of weather parameters on the incidence of cassava mealybug *Phenacoccus manihoti* (Matile-Ferrero) was studied in 2023 on five different cassava varieties in Tamil Nadu, India. A random survey was conducted where pest damage and pest incidence were correlated with weather parameters like maximum temperature, minimum temperature, and rainfall. Peak activity of mealybug and its damage was recorded on the 16th SMW (0.87) and on the 18th SMW (1.24) respectively. Tapioca variety Mulluvadi was susceptible and Yethapur 2 was resistant to cassava mealybug. Weather parameters contributed 71 per cent variation (R2 = 0.71) in the total mean population and 72 per cent variation (R2 = 0.72) in total mean damage. In Mulluvadi variety, mealybug population had a positive correlation with temperature (r=0.69) and a negative correlation with relative humidity (r=0.74). Mealybug damage was positively correlated with minimum temperature (r=0.80) in cassava variety Sree Raksha.

Keywords: *Phenacoccus manihoti*, Cassava, seasonal incidence, damage, correlation.

INTRODUCTION

Cassava, scientifically known as *Manihot esculenta*, is a woody shrub native to South America. Due to its nutritional value, capacity to adapt to a wide range of climates, and numerous industrial applications, this versatile crop has become more important on a global scale. India ranks fifth in the world for cassava production. Tamil Nadu is India's largest cassava-producing state, with a 51.9% area and 57.8% productivity (Sampathkumar *et al.*, 2021). The cassava mealybug *Phenacoccus manihoti* Matile-Ferrero (Hemiptera: Pseudococcidae) is a significant pest on cassava worldwide and it causes up to 80 per cent yield loss (Joshi *et al*., 2020). It was first introduced to Asia (Thailand) in 2009 and then to Africa in the early 1970s, where it quickly established itself as the world's most destructive pest of cassava (Neuenschwander, 2001; Calatayud and Le Ru 2006; Winotai *et al*., 2010). In India, it was first discovered in Tamil Nadu and then in Kerala (Gupta *et al*., 2020; Sampathkumar *et al*., 2021). This reddish mealy coated insect typically infests the shoot tip and underside of the leaves which resulted in the sprouting of adventitious buds on almost all internodes further leading to drying and complete defoliation of the plant.

Naturally, the population level and severity of damage of an insect pest are highly influenced by the environmental factors present in the area (Becker, 1974). While developing viable and sustainable management strategies to manage pests, the impact of these environmental factors on the occurrence and development of pests is very crucial. Though the environmental impact is confounded, temperature and rainfall are the chief factors that decide the occurrence, development, and survival of the insect pest. Many authors earlier reported the relationship between pests and weather factors on various crops in Tamil Nadu (Saminathan *et al*., 2001; Prianka *et al*., 2016; Anandhi *et al*., 2020). The response of the different cultivable cassava varieties to cassava mealybug also variesin relation to climatic conditions. However, the availability of documented data on this aspect in Tamil Nadu condition is very limited as *P. manihoti* is a new pest in Tamil Nadu. Hence it is essential to comprehend the effect of weather factors on the pest while creating management approaches that are cost-effective.

MATERIAL AND METHODS

The quantitative pest data on the population of Cassava mealybug and its damage level on five different cassava varieties were recorded in the cassava fields available in Tapioca and Castor Research Station, Yethapur. The varieties surveyed were Mulluvadi, White Thailand, YTP-1, YTP-2, and Sree Raksha which are the common varieties grown by farmers in Tamil Nadu. The survey was started on two months old plants and observations were recorded from the 14th Standard Mean Week to the 30th Standard Mean Week (The first fortnight of April to the second fortnight of July). In each variety, a random survey of 40 plants was made in the field by following the "W" pattern (Prasanna *et al*., 2018) and observations were recorded based on the population scale and leaf-damage scale (CIAT, 1983) (Table 1). In all the varieties, fields that were maintained free of chemical pesticides were selected for the survey. Data on abiotic factors such as maximum and minimum temperature, rainfall, relative humidity, and wind speed were collected corresponding to their sampling periods from TCRS, Yethapur. The quantitative relationship of the fortnightly mean mealybug population scale and damage scale with weather parameters *viz*. maximum and minimum temperatures, humidity, wind speed, and rainfall were worked out and expressed in the form of mathematical equations. The quantitative influence of each weather parameter on the population and damage scale of all varieties were separately worked out. Correlation studies were analysed using R software and regression analysis was carried out using SPSS Software.

RESULTS AND DISCUSSION

A. Seasonal fluctuations

The average *P. manihoti* population and its damage fluctuated on all the varieties depending upon the variations in weather parameters. The mealybug incidence and damage were recorded thorough out the survey period starting from the 14th SMW to the 30thSMW. The average mealybug population scale for all five varieties gradually increased from the 14th SMW (0.37) and peaked in the 16th SMW (0.87) and then decreased gradually and reached (0.2) during the 30th SMW (Fig. 1). This was in accordance with the findings of Kumar *et al*. (2021) who reported that high incidence of mealybugs occurred in the month of April. The high temperature with low rainfall prevailed during the 16th SMW (*i.e*. during the dry season) might have increased the mealybug population (Hennessey *et al*., 1990; Sampathkumar *et al*., 2021). Cassava has the ability to grow under drought conditions. The plant resistance to insects decreased during the dry season and thereby plants became more favourable to mealybug (Paul-Andre Calatayud and Bruno Le Ru 2006; Ngeve, 2003). The Photosynthesis of plants increases as temperature increases which simultaneously increases the atmospheric CO_2. Coley and Markham (1998) reported that an increase in CO_2 level in the atmosphere declines the nutritional quality of the leaves by diluting 10-30 % nitrogen content which could cause increased food consumption by herbivores. The population scale of mealybug was reduced drastically in the 18th SMW (0.53) due to the rain (12.30 mm) and again shoot up in the next week (20th SMW) (0.56) due to the increased temperature (37.6ºC) and low rainfall (2.20mm) and subsequently population decreased due to incidence of rainfall. This result was in accordance with the findings of Schuless (1987) who studied the interactions between cassava mealybug populations with weather parameters and concluded that cassava mealybug suffered mortality during the rainy season. The mealybug population varied among different varieties during the entire survey period. Mulluvadi variety (1.94 per plant) recorded the highest mealybug incidence during the 16th SMW followed by YTP 1(0. 93) and White Thailand (0.83). Sree Raksha (0.32) and YTP 2 (0.27) harbouredless mealybug population during the same period (Fig. 2). Sampathkumar *et al*. (2021); Kumar *et al*. (2021) discovered that the setts which were planted from November to January had a high incidence of the pest when compared to setts planted from March to June. Their findings correlated with our results that Mulluvadi which was sown during January had a high incidence when compared to other varieties. Lema and Herren (1985) suggested that the ideal temperature for the growth of *P. manihoti* was probably between 27 and 30°C beyond the ideal temperature no development occurred. In contrast, the present investigation indicates that the *P. manihoti* population could persist within the range of 35-37°C.

The damage started after the incidence of the mealybug. The average damage started in the 14th SMW (0.56) and attained a peak at the 18th SMW (1.24) and declined in the subsequent weeks (Fig. 1). The damage was higher during 16th SMW in the Mulluvadi (2.04) and YTP 2 (0.72), during 18th SMW in YTP 1 (1.60) and White Thailand (1.16), and during 20th SMW in Sree Raksha (1.68). Among all varieties, TNAU released variety YTP2 registered very less damage (0.22) (Fig. 3) and less incidence of the pest (0.05) followed by CTCRI released variety Sree Raksha. These recently released varieties were resistant to cassava mosaic diseases and also showed less susceptibility to mealybug. This could be due to the existence of favourable secondary metabolites as discovered by Calatyud *et al*. (1994). Mulluvadi variety was highly susceptible to *P. manihoti* when compared to white Thailand which was in line with the findings of Elangovan *et al*. (2022) and Kumar *et al*. (2021).

B. Correlation and Regression studies

Relative humidity had a significant and negative correlation with the mealybug population of YTP 2 (r =0.70), and Mulluvadi (r = 0.68) and maximum temperature had a significant and positive correlation with the mealybug population of Mulluvadi (r=0.69). The Correlation was significant at a 5 % level. The result of correlation studies agreed with Hazarika (2020); Gaikwad (2018); Ankitha Singh (2012) who stated that mealybugs were found to have a positive correlation with maximum temperature and negatively correlated with relative humidity. Similar findings were reported by Angu (2017); Harde (2018); Akhter *et al*. (2022). All other weather factors had no significant influence on the mealybug population of cassava (Fig. 4). Rainfall had non-significant and negative correlation with the mealybug population in all varieties. Cudjoe (1990) also stated that rainfall was negatively correlated with mealybug population. According to Parsa *et al*. (2012), *P. manihoti* disseminated to nearby plants by wind, but in our study negative correlation was observed with the mealybug population. This could be attributed to the reduced availability of fresh palatable young leaves to mealybugs as the dry wind during summer might have transpired the moisture from cassava leaves. Minimum temperature had a significant and positive correlation with mealybug damage of Sree Raksha (r=0.80) and mealybug damage of other varieties had a non-significant correlation with weather parameters (Fig. 5). Correlation studies of damage with weather parameters were not highly influential.

The Regression analysis was carried out using SPSS Software where weather factors are considered as the independent variable, while varieties as the dependent variable. (Tables 2 and 3). The linear models explained that 88,54,60,76, and 54 per cent variations in mealybug population and 75,93,62,76, and 85per cent variations in mealybug damage were due to weather factors for Mulluvadi, White Thailand, YTP1, YTP 2 and Sree Raksha. All the weather parameters together were jointly responsible for 71 per cent variation (R2=0.71) in total mean population and 72 per cent variation (R2=0.72) in total mean damage. These results are in conformity with Sitaramaraju *et al*. (2010).

Table 1: Population and leaf-damage scale for mealybug.

Sr. No.	Scale	Population	Damage
1.	0	No biological stage	No damage
2.	1	Presence of nymph on growing shoot	Small undulations in the margins of apical leaves
3.	2	Presence of nymph and adult on growing shoot	Slight curling of leaves on the growing shoot
4.	3	Presence of ovisacs and biological stages on growing shoot	Rosetting and yellowing of leaves in growing shoot
5.	4	Presence of ovisacs and biological stages on growing shoot and leaves	Necrosis and death of apical leaves. Sooty mold is often present
6.	5	Presence of nymphs, adults, and ovisac on all plant parts	Death of growing shoot, plant defoliation Presence of sooty mold.

Table 2: Effect of weather factors on population of Cassava mealybug *Phenacoccus manihoti* (Matile-Ferrero) during 2023.

Variety	R^2 value	Regression equation
Mulluvadi	0.880	$Y=9.542+.152x_1+-0.514x_2+-0.008x_3+-0.020x_4+-0.58x_5$
White Thailand	0.546	$Y=2.790+0.35x_1+-0.113x_2+-0.005x_3+-0.008x_4+-0.28x_5$
YTP 1	0.602	$Y=5.851+-0.65x_1+-0.006x_2+-0.005x_3+-0.37x_4+-0.39x_5$
YTP 2	0.761	$Y=2.646+-0.002x_1+-0.072x_2+-0.000x_3+-0.11x_4+-0.13x_5$
Sree Raksha	0.540	$Y=0.602+0.025x_1+-0.45x_2+-0.03x_3+-0.00x_4+-0.12x_5$
Average	0.711	$Y=4.298+.031x_1+-0.154x_2+-0.003x_3+-0.015x_4+-0.03x_5$

(x_1-Max temx_2-Min; temx_3- Rainfall x_4-Rel; Hum x_5-Wind speed)

Table 3: Effect of weather factors on damage of Cassava mealybug *Phenacoccus manihoti* (Matile-Ferrero) during 2023.

Variety	R^2 value	Regression equation
Mulluvadi	0.759	$Y=10.141+-0.035x_1+-0.143x_2+-0.014x_3+-0.067x_4+-0.031x_5$
White Thailand	0.936	$Y=-1.311 +0.154x_1+0.368x_2+0.002x_3+-0.008x_4+-0.28x_5$
YTP 1	0.622	$Y=-6.187+-0.028x_1+0.381x_2+0.019x_3+-0.032x_4+-0.059x_5$
YTP 2	0.765	$Y=5.588+0.010x_1+-0.159x_2+0.008x_3+-0.035x_4+-0.005x_5$
Sree Raksha	0.855	$Y=-16.435+-0.019x_1+0.702x_2+0.014x_3+0.00x_4+0.100x_5$
Average	0.720	$Y=-1.641+-.045x_1+0.230x_2+0.011x_3+-0.029x_4+0.019x_5$

(x_1-Max temx_2-Min temx_3-Rainfall x_4-Rel Hum x_5-Windspeed)

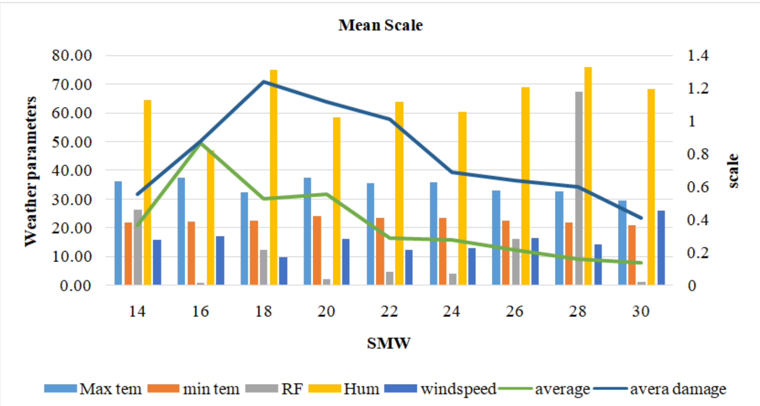

Fig. 1. Seasonal variation of the Cassava mealybug *P.manihoti* population and damage during 2023.

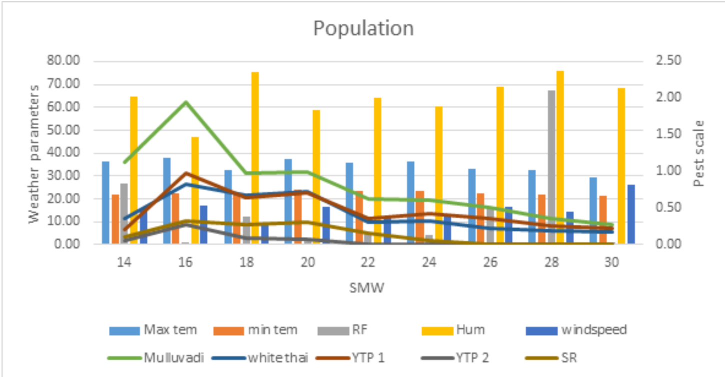

Fig. 2. Seasonal variation of the Cassava mealybug *P. manihoti* population during 2023.

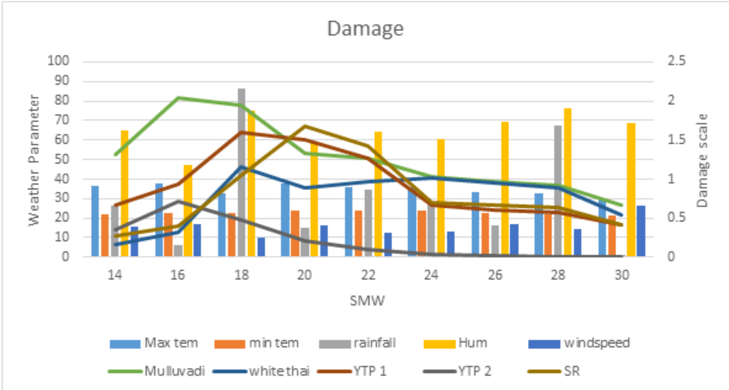

Fig. 3. Seasonal variation of the Cassava mealybug *P. manihoti* damage during 2023.

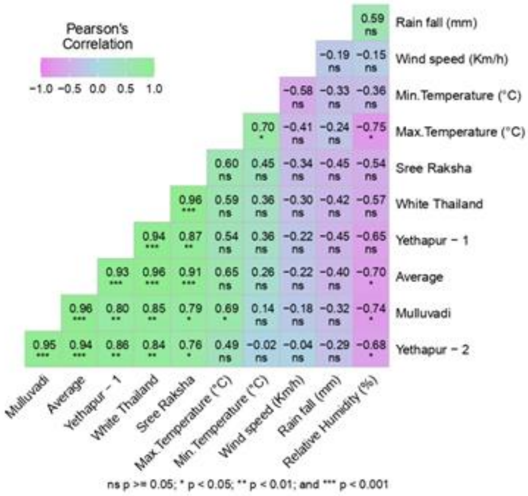

Fig. 4. Influence of weather factors on Cassava mealybug *P. manihoti* population during 2023.

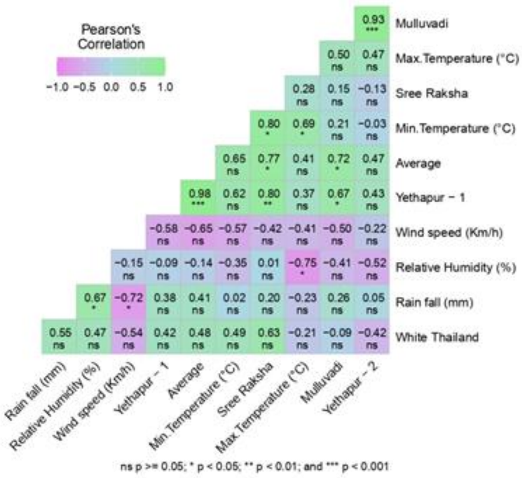

Fig. 5. Influence of weather factors on Cassava mealybug *P. manihoti* damage during 2023.

CONCLUSIONS

The Cassava mealybug *P. manihoti* population was high during the summer season. Maximum temperature was positively correlated and humidity was negatively correlated with mealybug incidence. Therefore, it can be established that high temperature favors a high population of mealybug whereas, rainfall and relative humidity reduce the incidence of pest. Mulluvadi variety which was one of the highly preferred varieties by farmers harboured a high incidence of mealybug. So, resistant varieties, timely sowing, and proper irrigation must be taken into consideration before planting cassava.

FUTURE SCOPE

The future scope for studying the seasonal incidence of cassava mealybug involves climate impact analysis, long-term trend identification, predictive modeling, cultivar resilience assessment, community engagement, and global collaboration. This can lead to targeted interventions, resilient crop varieties, and innovative pest management solutions.

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Conflict of Interest. None.

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