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A NOVEL DAMAGE INTENSITY INDEX FOR TEA MOSQUITO BUG *HELOPELTIS* SPP. INFESTATION IN COCOA

Shivaji Hausrao Thube[3,4], R T P Pandian[1], C T Jose[1], Bhavishya A[1], Santhoshkumar Paichal[1], Omprakash Navik[2], Akash Nikoshe[3] and G K Mahapatro[4*]

[1]ICAR-Central Plantation Crops Research Institute, Regional Station, Vittal 574243, Karnataka, India
[2]ICAR-National Bureau of Agricultural Insect Resources, Bengaluru 560024, Karnataka, India
[3]ICAR-Central Institute for Cotton Research, Nagpur 440010, Maharashtra, India
[4]ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi 110012, India
*Email: gagan_gk@rediffmail.com (corresponding author): ORCID ID 0000-0002-9235-1814

ABSTRACT

The present investigation focused on the development of a new damage intensity index (DII) for the tea mosquito bug *Helopeltis* spp. (TMB) infestation in cocoa. The new DII was developed based on observable symptoms and the intensity of damage, such as the number and diameter of feeding lesions, and TMB-infested areas on cocoa pods. Statistical techniques, including linear correlation and regression, have been employed to develop an appropriate DII. The study reveals a significant correlation between the mean of total feeding lesions (Xn) and feeding lesions present on the middle portion (Xm) of cocoa pods, surpassing other combinations and indicating a strong relationship between these variables. The damage intensity was estimated using a linear regression approach resulting equation, Xn = 1.79 + 0.25Mn (R2 = 0.989), offers a quantified means of estimating damage intensity on cocoa pods. Analysis of infestation and the regression equation establishes DII values between 1.79 to 76.79. This novel index suggests that the minimum sample size of 90 pods is required for estimating a population with a 95% confidence level to arrive at precision decision making of TMB damage on cocoa pods. The novel damage intensity index and the calculated sample size from this investigation could be useful in conducting various studies, such as germplasm screening, breeding for pest resistance, evaluating the effectiveness of new insecticides, and formulating an IPM package for managing *Helopeltis* spp. in cocoa.

Key words: Decision making tool, tea mosquito bug, *Helopeltis* spp., Miridae, damage intensity index, cocoa, diameter, regression, sample size, indexing, feeding lesions, grading

Cocoa is an important cash crop and is commercially grown as a plantation crop in India (Thube et al., 2022a). In recent years, cocoa cultivation has faced various threats, including pests and diseases, inadequate irrigation, climate change, lack of quality planting material, and improper management (Thube et al., 2022b). Among these factors, insect pests and diseases play a crucial role in the low production and productivity of cocoa (Thube et al., 2019). More than fifty pest species have been documented in perennial cocoa stands in different cropping systems worldwide (Entwistle, 1972). In the context of climate change, the tea mosquito bug (TMB) species complex, including *Helopeltis theivora*, *H. bradyi*, and *H. antonii*, has emerged as a major threat to cocoa cultivation in India (Thube et al., 2019). In India, TMB is one of the most serious sucking insect pests of cocoa, causing up to 40% yield loss (Padi, 1997; CPCRI, 1993). TMB primarily infests the economically important part of cocoa, namely the pods, and even minimal damage from the insect pest can lead to significant quantitative and qualitative losses.

To make realistic decisions regarding economic thresholds and different pest management interventions, it is crucial to estimate the population density of the target pest (Mahapatro, 2008). Currently, no chemical insecticides are recommended by the Central Insecticide Board and Registration Committee (CIB&RC) for TMB management in the cocoa ecosystem in India. Over time, TMB has become a serious pest of cocoa, highlighting the urgent need for large-scale field trials on insecticides or bio-pesticides screening against TMB. However, without a reliable damage grading or intensity index, these screening trials cannot be conducted under field conditions. In the case of cashew, a widely adopted rating scale (0-4) for TMB was developed back in 1979 (Ambika et al., 1979), based on the necrotic lesions on nuts and shoots. However, the phenology, growth habits, and fruit characteristics of cashew and cocoa are vastly different, rendering this damage rating scale unsuitable for cocoa. Since the first report of TMB infestation in cocoa, no efforts have been made to develop a damage intensity index, indicating a research gap in the development of an appropriate decision support system. It is worth noting that TMB prefers to feed on developing pods over other parts of cocoa (Alagar and Bhatt, 2017; Thube et al., 2019; Thube et al., 2022a). The sample size plays a significant role in determining the precision of experimental results. The required sample size for a particular experiment depends on the sample variance and the level of precision desired by the experimenter for the specific characteristic of interest. Hence, this study aims to develop a new damage intensity index for TMB infestation on cocoa pods, along with determining the appropriate sample size.

MATERIALS AND METHODS

All the experiments under the present study are conducted at ICAR-Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka, India (12°45' N, 75°4' E; 90 m above mean sea level). Cocoa pods (N=100) were collected randomly from TMB infested gardens. Vertically, all the pods were equally divided into three portions viz., top (peduncle side), middle and bottom. Four squares (2 cm^2 size each) were equidistantly drawn in each portion. Number of feeding lesions in each square was measured from all three portions. Diameters of all the feeding lesions were measured under a stereomicroscope (Leica M10, equipped with an EC4 Digital camera). Area of the circular lesions was calculated using the formula $A = \pi r^2$, where, 'A' is the area and 'r' is the radius of the feeding lesion. Average number of lesions belongs to all squares of top, middle and bottom portions were denoted as Tn, Mn and Bn. The average number of feeding lesions belongs to squares of all portions (12 squares) were denoted as Xn. Average infested area belongs to all squares of top, middle and bottom portions were denoted as Ta, Ma and Ba. The average infested area belongs to squares of all portions (12 squares) were denoted as Xa. The correlation coefficient of different variables viz., Tn, Mn, Bn, Ta, Ma and Ba with Xn and Xa were worked out. Variables Xa and Xn were considered as the indicator for severity of the TMB infestation. Since, the computation of Xa and Xn are difficult, linear regression technique was used to estimate the value of Xa or Xn. The variables (Tn, Mn, Bn, Ta, Ma and Ba) having maximum correlation with Xa and Xn were used for index determination. The variable which gives maximum correlation coefficient was used in the linear regression model to estimate Xn or Xa (SPSS software, v. 15.0–IBM, Armonk, NY, USA). Damage intensity index (DII) was estimated based on the linear regression equation. Based on the DII, severity of the infestation was divided into four categories i.e., low, medium, high and severe. To determine the sampling size, key variable (mean number of feeding lesions from all four squares belongs to particular portion having the highest correlation with Xn i.e., Mn) was selected and observations on infestations were taken from 551 numbers of infested cocoa pods. Mean numbers of feeding lesions present on middle portion (Mn) of 551 cocoa pods were calculated. All the means obtained through 551 observations were further subjected to square root transformation. Variability in mean numbers of feeding lesions was calculated by determining the square root of the variance. Sample size was determined by using the following formula:

$$n = \frac{(1.96)^2 \sigma^2}{D^2}$$

where, n is sample size; 1.96 is the table value for 95% confidence level; σ^2 is variance of the population; 'D' is the margin of error expressed as 20% of mean and $\overline{x}$ is the mean number of feeding lesions on middle portion of pods.

RESULTS AND DISCUSSION

In the context of the ongoing investigations, a damage intensity index for TMB incidence in cocoa was formulated through the utilization of correlation and regression analysis. The correlation coefficients between Xn and Xa with other easily observable variables were analyzed and the results are presented in Fig. 1. The findings indicate that the correlation coefficient between Xn and Mn surpasses all other

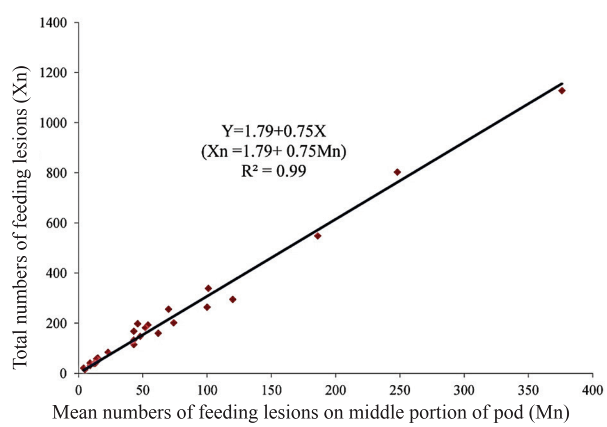

Fig. 1. Correlation between total infested area (Xa) and feeding lesions (Xn) with other variables

combinations, suggesting a strong relationship between these variables. In order to quantify the damage intensity, a linear regression technique was applied, treating Xn as the response variable and Mn as the independent variable. This regression analysis yielded the derived equation: Xn = 1.79 + 0.25Mn (R2 = 0.989), as depicted in Fig. 2. The calculated regression equation provides valuable insights into estimating the damage intensity index using the value of Xn. The DII is a crucial metric for assessing the severity of the pest

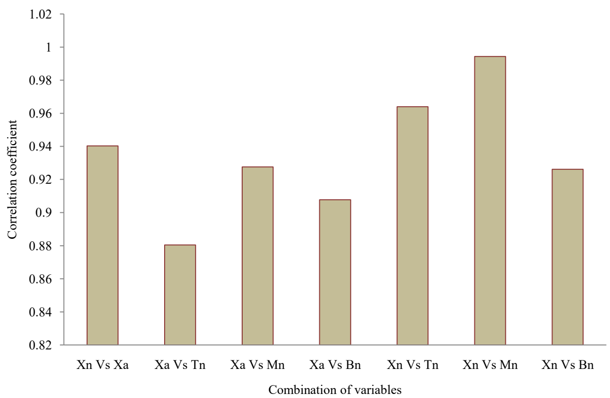

Fig. 2. Linear regression between total numbers of feeding lesions and mean number of feeding lesions on middle portion of infested pod

infestation. Based on the recorded observations and the regression equation, the values of the DII range from 1.79 to 76.79. These values serve as indicators of the extent of damage caused by the pest, with higher values indicating a greater severity of infestation. To facilitate the interpretation and categorization of the DII, the severity index is divided into four distinct groups based on mean number of feeding lesions/ 2 cm^2 of middle portion i.e., Low (<10 lesions), medium (10-25 lesions), high (25-50 lesions) and severe (>50 lesions). These categories are established based on the variation in damage observed and provide a practical framework for assessing the level of damage severity. The results obtained through the correlation analysis, regression analysis, and subsequent categorization of the DII enhance our understanding of the relationship between the variables and the severity of pest infestation. These findings can have practical implications for managing and mitigating the impact of the pest, allowing for more effective decision-making and intervention strategies in pest control and crop protection.

The study on 551 pods found mean lesions in middle squares: 1.6; variance: 2.4. Setting a 20% error margin (D) on mean, determined a 90-pod as a future sample size (minimum). Specifically, the sample size of 90 determined in this study will yield an estimate of the infestation intensity with a 20% margin of error. These findings contribute to the development of effective sampling methodologies and research protocols in the field of pest management. By considering the variability in the number of feeding lesions and the desired level of precision, researchers can confidently determine the appropriate sample size needed to accurately assess and monitor the infestation intensity in cocoa. It is worth emphasizing that having a well-defined sample size enhances the reliability and validity of the study results. The determined sample size of 90 pods provides a balance between obtaining a representative sample and ensuring a manageable workload for data collection and analysis.

No prior studies on cocoa TMB intensity measurement exist, highlighting DII significance. It aids germplasm screening, pest-resistant breeding, new insecticide evaluation, and IPM strategy formulation. DII accurately gauges TMB infestation, identifying resistant cocoa types. It assesses insecticide efficacy and aids tailored IPM for cocoa crops. The DII ensures timely and efficient control measures, minimizing damage and optimizing yield. In summary, the novel DII developed in this study fills a significant research gap by providing a reliable and standardized measure of TMB incidence intensity in cocoa. Its utilization extends beyond this study, enabling advancements in various areas of research and practical application, ultimately contributing to the sustainable management of TMB and improving cocoa production outcomes.

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AUTHOR CONTRIBUTION STATEMENT

SHT and GKM conceived and designed the research, and have equally contributed. SHT, RTPP and SKP conducted experiments and wrote the manuscript. CTJ analysed the experimental data. BA, ON and AN contributed in writing and editing the manuscript. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

REFERENCES

Alagar M, Bhat K. 2017. Comparison of biology of tea mosquito bug, *Helopeltis bradyi* Waterhouse (Hemiptera: Miridae) on different phenological stages of cocoa (*Theobroma cacao* L.). Journal of Plantation Crops 45(3): 155-161.

Ambika B, Abraham C C, Vidyadharan K K. 1979. Relative susceptibility of cashew types to infestation by *Helopeltis antonii* Sign. (Heteroptera: Miridae) In: Proceedings of PLACROSYM II; 26–29 June 1979, Ootacamund, India. pp. 513-516.

CPCRI. 1993. Annual report, Central Plantation Crops Research Institute, Kasaragod, Kerala, India. pp. 82-83.

Devasahayam S. 1985. Seasonal biology of tea mosquito bug *Helopeltis antonii* Signoret (Heteroptera: Miridae): a pest of cashew. Journal of Plantation Crops 13: 145-147.

Entwistle P F. 1972. Pests of Cocoa. Tropical Science Series. Longman, London, UK. 779 pp.

Mahapatro G K. 2008. A refined damage rate scoring method for tea mosquito bug infestation in cashew. Indian Journal of Entomology 70(3): 273-277.

Padi B. 1997 Prospects for the control of cocoa capsids – alternatives to chemical control. In: Proceedings First International Cocoa Pests and Diseases Seminar, Accra, Ghana, 6-10 November, 1997. pp. 28-36.

Thube S H, Mahapatro G K, Mohan C, Pandian R T P, Apshara E, Jose C T. 2019. Biology, feeding and oviposition preference of *Helopeltis theivora*, with notes on the differential distribution of species of the tea mosquito bug species complex across elevations. Animal Biology 70(1): 67-79.

Thube S H, Pandian R T P, Babu M, Josephrajkumar A, Mhatre P H, Kumar P S, Nirmal Kumar B J, Hegde V, Chavan S N. 2022a. Evaluation of a native isolate of *Metarhizium anisopliae* (Metschn.) Sorokin TMBMA1 against tea mosquito bug, *Helopeltis theivora* infesting cocoa (*Theobroma cacao* L.). Biological Control 170: 104909. https://doi.org/10.1016/j.biocontrol.2022.104909.

Thube S H, Pandian R T P, Josephrajkumar A, Bhavishya A, Kumar B N, Firake D M, Shah V, Madhu T N, Ruzzier E. 2022b. *Xylosandrus crassiusculus* (Motschulsky) on Cocoa Pods (*Theobroma cacao* L.): Matter of Bugs and Fungi. Insects 13(9): 809. https://doi.org/10.3390/insects13090809.

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