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# Occurrence of Major Pests on the Trimmed Surface of Tea Plants in Relation to Temperature and Relative Humidity -An Approach Towards Minimal Use of Pesticides

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## ABSTRACT

Assemblage of tea pests were studied in relation to environmental factors aiming at working out conditions promoting maximum occurrence on the surface of trimmed tea plants and thereby ensuring minimal use of pesticides and damage to the human workers resulting from chemicals. Atmospheric temperature and relative humidity tended to render a positive impact on the occurrence of the pests on plant surfaces, as indicated by correlation analyses, regression lines and the principal component analysis.

**Keywords** Arthropods, Environmental factors, Health issues, Tea pests.

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## INTRODUCTION

Even in the era of grooming and materializing the concept of sustainable ecotourism in the tea gardens using artificial intelligence (Hou and Wen 2021, Yang *et al*. 2021) the socioeconomic condition of the tea garden-workers in several parts of India has remained poor in view of income, health and hygiene and standard of living (Sharma and Bhuyan 2016, Perumal 2021, Rajput *et al*. 2021). Several health hazards, ranging from damage of lungs to birth defect, as a direct result from exposure to pesticides, have remained a matter of grave concern till date (Kumar *et al*. 2020, He *et al*. 2022, Puzari and Nath 2022).

Studies revealed that the tea is the second-highest beverage in terms of consumption throughout the world (Engelhardt 2013, Zayadi *et al*. 2016, Sen *et al*. 2020, Zeng *et al*. 2020) and its demand is growing up worldwide (Fang *et al*. 2019, Bora *et al*. 2019). Hundreds of chemicals including polysaccharides, amino acids, vitamins (C, E and K), flavonoids and caffeine have been reported to be present in the leaves of the tea plants (*Camellia sinensis* (L.) O. Kuntze) (Shen amd Chen 2008, Bhagat 2010). Though in natural conditions, the tea plants may reach up to a height of 15m, the height of the plants cultivated is maintained within 60 cm to 100 cm (Chaliha and Kalita 2020). Tea plants are susceptible to various pests as it a monoculture and perennial type of crop and more than one thousand species of arthropods are observed to be associated with the tea plants of which, the pests, left uncontrolled, may cause a loss amounting from 11% to 55% of the total yield (Hazarika *et al*. 2009). Mitra *et al*. (2018) have recorded 167 species under 139 genera belonging to 42 families and 6 orders of insects during the survey conducted in tea gardens of North Bengal.

India shares 23% of the world's total production of tea using an area of 400,000 hectares of land for tea plantation, while West Bengal is the second largest producer of the states of India sharing around 24% of the national production (Sadhukhan 2014, Chaliha and Kalita 2020). In northern part of Bengal small tea growers account for the 32.5% of the total production of the region (Chowdhury *et al*. 2016).

Pesticides, commonly used in tea gardens, render severe detrimental impact on the ecosystem and the human workers ranging from neurological disorder, organ damage to birth defect (Philippat *et al*. 2018, Dutta and Bahadur 2019, Kumar *et al*. 2020, He *et al*. 2022).

Current work was attempted as an approach towards preparing an information-base to ensure maximum effect from a pesticide with a timely and minimal use and thereby reducing the detrimental impact on the human workers exposed to it. It appears possible to achieve by timely application of the pesticide spray when a maximum number of pests are exposed and environmental factors might be playing a key role promoting the assemblage of the pests on the surface part of the cultivated plants. Current paper aims to address this aspect.

## MATERIALS AND METHODS

Three sampling plots at a privately managed tea-garden, within 26°33/ 30.15// to 26°33/ 26.71// N and 88°41/ 54.29// to 88°42/ 1.64// E. Elevation was around 292 ft from msl, were selected for the study. The study was conducted by the author on five occasions during the month of February and March, 2017 at one-week intervals. The span was kept short to minimize the effect of temporal factors and prioritize the impact of climatic factor. Each survey was conducted within 4:00 PM to 5:00 PM. Though for a better insight, intra-day variation in respect to the environmental factors appears necessary, there however, would remain implication of circadian behavioural pattern of the pests coupled with temporal variation of weather that would bring forth greater complexity in view of preliminary investigation. It was therefore left out of scope of the current study but will be incorporated essentially in future broad-scale study both in temporal and spatial terms.

No pesticides were used during the study period. Number and varieties of pests encountered on the trimmed surfaces of a total of thirty tea plants, ten from each of the three sites, were recorded from during every study effort on each occasion of the ten plants, two plants were selected at each of the four corners and two from the middle of every site.

Air temperature and relative humidity were recorded with a digital temperature and humidity meter. For identification of pests, available literatures for tea-pests in the region of the current study were followed (Shrestha and Thapa 2015, Muraleedharan and Roy 2016, Deka *et al*. 2021).

Statistical software MINITAB 13 was used for numerical analyses. Logarithmic transformation of raw data was made as per the requirement of parametric statistical analysis (Gerard and Berthet 1996).

## RESULTS AND DISCUSSION

Four different types of pests were recorded from the study sites. Those were- *Hyposidra talaca* (Black inch worm), *Helopeltis thevora* (Tea mosquito bug), *Toxoptera aurantii* (an aphid) and *Oligonychus coffeae* (Red spider mite) (Table 1). Fluctuation of

**Table 1.** Types of pests recorded during the study and the nature of damage.

| Pest | Stage | Nature |
|---|---|---|
| *Hyposidra talaca* (Black inch worm) | Young and mature larva | Holes in the margins of tea leaves, defoliation |
| *Helopeltis thevora* (Tea mosquito bug) | Nymph and adult | Young leaves, buds are lost |
| *Toxoptera aurantii* (Aphid) | Nymph and adult | Buds and leaves are damaged |
| *Oligonychus coffeae* (Red spider mite) | Nymph and adult | Leaves turn browish, defoliation |

**Table 2.** Temperature, moisture and the numerical abundance recorded during the study period (logarithmically transformed).

| | | Temperature (°C) | Relative humidity (%) | Abundance of pests |
|---|---|---|---|---|
| DAY1 | S-I | 3.19 | 4.29 | 1.79 |
| | S-II | 3.18 | 4.33 | 1.79 |
| | S-III | 3.16 | 4.33 | 2.48 |
| DAY2 | S-I | 3.22 | 4.34 | 3.14 |
| | S-II | 3.27 | 4.39 | 2.2 |
| | S-III | 3.19 | 4.37 | 3 |
| DAY3 | S-I | 3.23 | 4.38 | 2.4 |
| | S-II | 3.26 | 4.34 | 1.79 |
| | S-III | 3.26 | 4.36 | 2.89 |
| DAY4 | S-I | 3.21 | 4.36 | 2.2 |
| | S-II | 3.22 | 4.37 | 1.79 |
| | S-III | 3.18 | 4.38 | 0.69 |
| DAY5 | S-I | 3.31 | 4.43 | 2.48 |
| | S-II | 3.26 | 4.45 | 3 |
| | S-III | 3.28 | 4.41 | 2.3 |

atmospheric temperature and relative humidity are given in Table 2 (logarithmically transformed numerical values).

The temperature ranged from 23.5 °C to 27.3°C while the moisture varied from73% to 86.4% (Fig.1).

The total number of pests recorded at the sampling sites ranged from 6 to 23 per effort (Fig.2). *Buzura suppressia* was the most abundant species followed by *Toxoptera aurantii* (Fig 3- 4).

**Statistical analysis:** T-test indicated there were no statistically significant differences in abundances between the sites (Table 3).

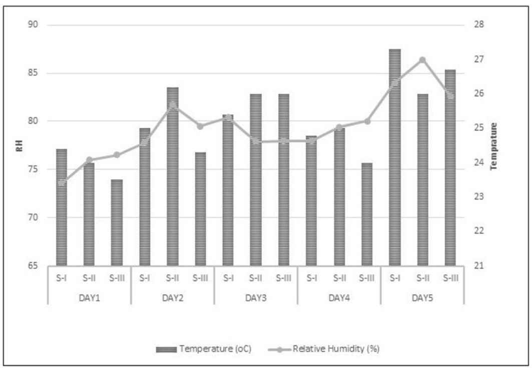


**Fig. 1.** Temperature and moisture at the study sites during the study.

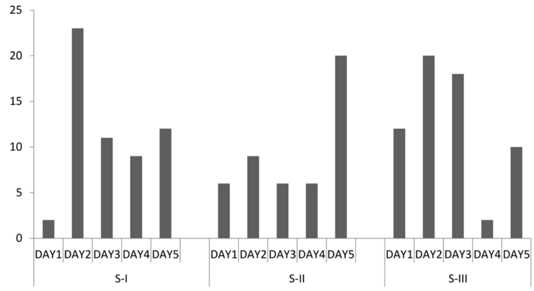


**Fig. 2.** Fluctuation of total abundances of pests recorded at the study sites.

One-way ANOVA revealed no statistically significant variation of abundance data recorded from the sites (p>0.05) (Table 4).

According to multiple correlation analysis on over-all data (taking sites-I, II and III together), abundance, RH and temperature appeared positively correlated to one another but, the statistically significant correlation existed only between temperature and RH (Table 5).

At site-I positive and negative values of correlation coefficients for moisture and RH respectively with the pest abundance were obtained but none of them was statistically significant (p>0.05).

At sites-II and III, correlation coefficients indicated a negative impact of RH and temperature on pest abundance but here also the observation was not significant.

The model estimated by the multiple regression

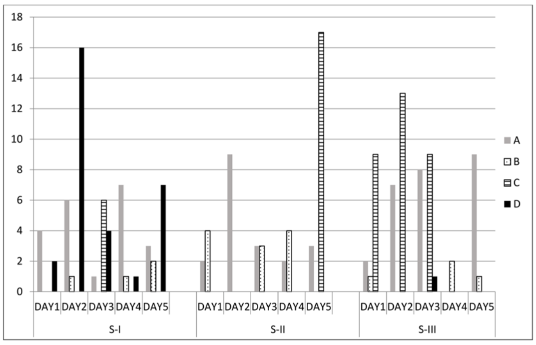


**Fig. 3.** Abundances of pests (species-wise) at the sampling sites (A= *Hyposidra talaca*, B= *Helopeltis thevora*, C= *Toxoptera aurantii*, D= *Oligonychus coffeae*).

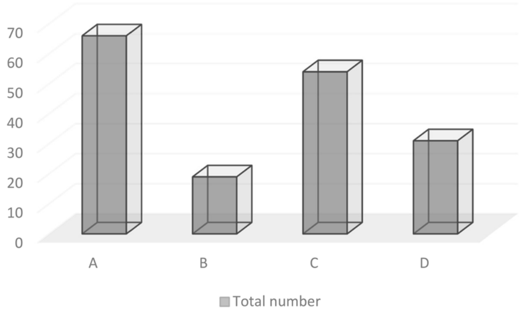


**Fig. 4.** Shows the total number of pests observed (A= *Hyposidra talaca*, B= *Helopeltis thevora*, C= *Toxoptera aurantii*, D= *Oligonychus coffeae)*.

analysis, as ANOVA indicated, was not significant ($p > 0.05$). $R^2$ value (Coefficient of determination) showed that the predictors included could account for a very small part of the variation of the abundance (Table 6). The regression lines taking the temperature and the relative humidity as the independent variables and the abundance as the response, exhibited positive slopes, but both of factors separately appeared limited role as the $R^2$ indicated and relative humidity rendered less impact in comparison to the temperature (Fig 5, 6). Principal component analysis substantiated the above observations as the angle between the selected factors and the abundance was close to $90^o$ indicating insignificant positive correlation between them and the angle was less between the temperature and the abundance indicating greater influence than that of relative humidity. The first and the second component could present more than 88% of the variability of the data obtained (Fig.7)

Dry atmosphere and high temperature, in general, exhibit a negative impact on insect abundance (Matilda *et al*. 2012, Jaworski and Hilszczańsk 2013).

**Table 3.** Result of T-test (unpaired) for the difference of abundances of pests recorded at the sampling sites (AB1, AB2, AB3 = Abundances of sites-I, II and III respectively).

T-Test: AB1, AB2
T-Test of difference = 0 (vs not =): T-Value = 0.71 P-Value = 0.503

T-Test: AB1, AB3
T-Test of difference = 0 (vs not =): T-Value = -0.05 P-Value = 0.964

T-Test: AB2, AB3
T-Test of difference = 0 (vs not =): T-Value = -0.72 P-Value = 0.497

**Table 4.** Result of one way ANOVA on the abundances of pests recorded at the sampling sites.

One-way ANOVA: S-I, S-II, S-III

Analysis of variance

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Factor | 2 | 0.208 | 0.104 | 0.23 | 0.800 |
| Error | 12 | 5.500 | 0.458 | | |
| Total | 14 | 5.708 | | | |

```
                                Individual 95% CIs for mean
                                based on pooled StDev
Level   N   Mean    StDev  -+---------+---------+---------+-----
S-I     5   2.4015  0.4897      (------------*------------)
S-II    5   2.1136  0.5234      (------------*------------)
S-III   5   2.2733  0.9281     (------------*-------------)
                           -+---------+---------+---------+-----
Pooled StDev =  0.6770     1.50      2.00      2.50      3.00
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DF = Degree of freedom, SS = Sum of square, MS = Mean square, F = F statistics, StDev = Standard deviation, CIs = Confidence intervals.

[Individual confidence intervals given in dotted line indicate (with 95% confidence) the probable range of occurrence of the mean. The asterix in the middle of the line marks the present mean. The ranges of mean within parentheses not overlapping implies that those means are different and not different if the ranges overlap].

Role of environmental factors in population abundance, diversity and distribution of pests have drawn attention of several workers. Impact of shifting

**Table 5.** Multiple correlation analyses between the abundances of pests, relative humidity and temperature (on collective data). The first one is on collective data from all the sites, the second, third and fourth analyses are on data form site-I, site-II and site-III respectively.

Correlations: AB, RH, TEMP

| | AB | RH |
|---|---|---|
| RH | 0.258 | |
| | 0.353 | |
| TEMP | 0.300 | 0.670 |
| | 0.278 | 0.006 |

Cell contents: Pearson correlation P-Value

Correlations: S-I, RH1, T1(total)

| | S-I | RH1 |
|---|---|---|
| RH1 | 0.277 | |
| | 0.652 | |
| T1 | -0.134 | 0.763 |
| | 0.829 | 0.133 |

Cell contents: Pearson correlation P-Value

Correlations: S-II, RH2, T2

| | S-II | RH2 |
|---|---|---|
| RH2 | -0.106 | |
| | 0.865 | |
| T2 | -0.352 | -0.392 |
| | 0.562 | 0.514 |

Cell Contents: Pearson correlation P-Value

Correlations: S-III, RH3, T3

| | S-III | RH3 |
|---|---|---|
| RH3 | -0.711 | |
| | 0.178 | |
| T3 | -0.184 | 0.673 |
| | 0.767 | 0.213 |

Cell contents: Pearson correlation P-Value

RH1, RH2, RH3= Relative humidity recorded at sites-I, II and III respectively.
T1, T2, T3= Temperatures recorded at sites-I, II and III respectively.

**Table 6.** Multiple regression analysis taking abundance (AB) as the dependent variable while air temperature (Tm) and Relative humidity (RH).

The regression equation: AB = - 14.5 + 1.13 RH + 3.66 Tm

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | -14.48 | 18.69 | -0.77 | 0.454 |
| RH | 1.126 | 5.713 | 0.20 | 0.847 |
| Tm | 3.663 | 5.376 | 0.68 | 0.509 |

S = 0.6590 R-Sq = 9.2% R-Sq(adj) = 0.0%

Analysis of variance

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Regression | 2 | 0.5285 | 0.2642 | 0.61 | 0.560 |
| Residual error | 12 | 5.2116 | 0.4343 | | |
| Total | 14 | 5.7401 | | | |

S = Standard distance of data values from regression line, R-Sq = Coefficient of determination, R-Sq (adj)= Coefficient of determination adjusted for the degree of freedom, T = t- statistics for testing null hypothesis coefficients equal to 0, P = p value of the tests, DF = Degree of freedom, SS = Sum of square, MS = Mean square, F = F statistic.

trends in magnitudes of environmental factors implicating with the variabilities of abundance, distribution and behavior of tea pests needs to be studied for proper management of tea pests (Roy *et al*. 2020). Studying stress on canopy with new and improved approaches, as have been attempted by several workers (Xian and Nigadrian 2021, Zhao *et al*. 2022) might be coupled with dynamics of environmental factors for wider and in-depth input to the knowledge-based monitoring and management strategy of tea pests.

Nymphs and adults of *Helopeltis* genera are observed to be more numerous and active as in the moist weather, they are more visible during the early and late hours of a day, while, for *Oligonychus coffeae*, high temperature and dry weather is more conducive (Nadda *et al*. 2013). Most of the tea pests exhibit shorter span life cycle producing more pests at a rapid pace during the wormer months causing more damage (Roy *et al*. 2019). Current work, though attempted for a shorter duration, corroborates this observation. Increasing temperature might be associated with elevated atmospheric $CO_2$ which also triggers higher occurrence of insect pests including *Toxoptera aurantii* resulting in more damage of plants by them other than deteriorating defense mechanism to some pests (Li *et al*. 2019, Ahammed *et al*. 2020, Pokharel *et al*. 2021).

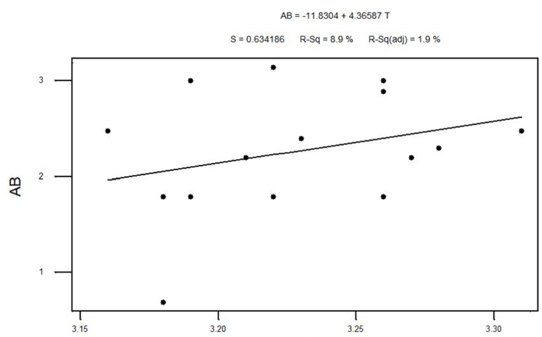


**Fig. 5.** Regression line of abundance (response) of pests in relation to temperature (AB= Numerical abundance, T= Temperature).

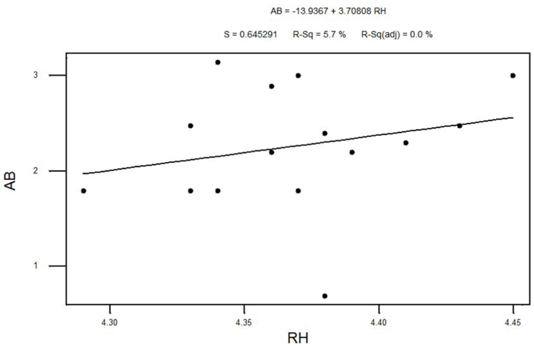


**Fig. 6.** Regression line of abundance (response) of pests in relation to relative humidity (AB= Numerical abundance, T= Temperature).

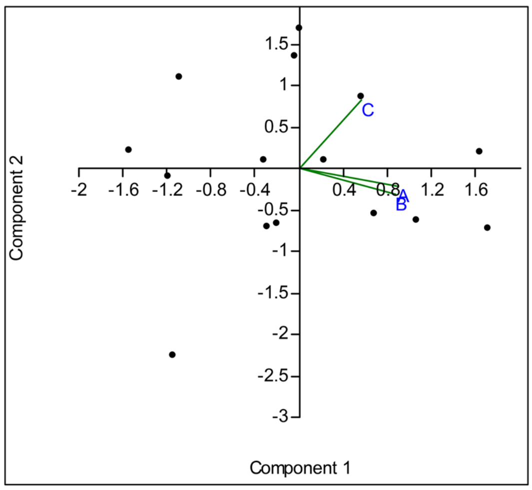


**Fig. 7.** Principal component analysis (A= Soil temperature, B= Soil moisture, C= Organic carbon, D= pH, E= Abundance of microarthropods).
(Component 1: Eigenvalue 1.83627, explains 61.209% of variance, Component 2: Eigenvalue 0.83044, explains 27.681% of variance)

However, the temperature of the area sampled, was not much high and varied within a moderate range, while, relative humidity was moderately high and varied within a limited range. The impact of these two factors therefore remained inconspicuous in the current work. Though a fixed time of sampling was maintained, daily activities of the pests, however, could be under the influence of the intensity of light also which was left out of the scope of the current work. An extensive study, involving more environmental factors including the level of atmospheric $CO_2$ and with longer durations therefore appears necessary to develop a comprehensive knowledge base for the purpose of minimizing the use of pesticides by enhancing their effectivity and thereby reducing the exposure of the workers to the same.

## CONCLUSION

The study was conducted for a short duration, in the environment with not so extreme variation or range of humidity and moisture. These are the probable reasons for not obtaining statistically significant relationship among the factors and abundance. It was however observed that the abundance of pests tended to increase in relation to the temperature and the humidity, within the range of the factors recorded. The time of use of the pesticides, therefore, might be chosen when air temperature and humidity is high within an optimum level and it is expected to vary according to the seasons and the locality. Other than specifying the chemical group most effective against targeted group, it is also important to determine the suitable time of application of the same yielding best result with minimal use and thereby reducing the harm to the garden-workers. Studies, preferably on hour-based or diurnal movement of pests, season-specific or of longer duration should be conducted at tea-gardens of every locality in relation to the prevailing environmental factors including the intensity of light and the level of $CO_2$ in air. By recording the time of the greater assemblage of pests with enhanced susceptibility to the pesticides in this way, the most preferable time for the application of pesticides bringing forth best result should be ascertained. Application of pesticides should be guided by such data generated from the area specific studies.

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