BIONOMICS, ABUNDANCE AND MANAGEMENT OF COFFEE WHITE STEM BORER (*Xylotrechus quadripes* Chervolet) IN NEPAL

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ABSTRACT

An experiment was conducted to study the life cycle, seasonal abundance and management practices of coffee white stem borer (Xylotrechus quadripes) at Horticulture Research Station, Kaski, Pokhara, Nepal from April, 2016 to October, 2019. The life cycle of coffee white stem borer was studied in laboratory by inoculation of first instar larvae into coffee branches up to adult emergence. The first instar larvae took 94±3 days to become adult. The monthly observation on the emergence of this borer showed that it was highly weather dependent and has two peak periods of emergence: April - June and September - November. Coffee white stem borer infestation was reduced to 11.11% with the application of treatments like scrubbing of stem and application of red soil mixed with fresh cow dung (1:1) or by stem scrubbing and application of Bordeaux paste on it followed by root zone application of Metarrhizium anisopliae (22.22%) or Beauveria bassiana (22.22%), or spraying of 10 % lime (22.22%). Proper and timely management practices during cultivation and selection of borer resistant genotype seem beneficial for the coffee growers. Further, application of borer management practices based on abundance models are recommended to minimize the pest infestation.

Keywords: *emergence, genotype, screening, weather*

INTRODUCTION

Coffee is a potential and emerging beverage crop of Nepal. Most of the coffee produced in Nepal is organic and have been exported in overseas market like Japan, Korea, Canada, USA, etc. The area under coffee production has increased up to 2650 ha in fiscal year 2018/19 with green bean production of 530 tons (NTCDB, 2019). GIS survey report shows that 1.19 million hectares is suitable for coffee cultivation but only less than 0.3% of land has been used for cultivation in Nepal (NTCDB, 2018). Coffee growers are facing coffee white stem borer *Xylotrechus quadripes* Chervolat (Cerambycidae, Coleoptera) as a major threat to coffee cultivation which accounted for nearly 60% economic yield losses of coffee in Nepal (Acharya and Dhakal, 2014). Khadge et al. (2004) reported that yield loss due to coffee white stem borer ranges from 10 to 80% in major coffee growing districts; Syangja, Gulmi, Palpa and Kavrepalanchok. The tetraploid and autogamy nature of Arabica coffee with narrow genetic base, multiplied through inbreeding, makes vulnerable to different insect pests and diseases as compared to genetically large and outbreeding species *Coffea robusta* (Lashermes et al., 1999). In Nepal, Bourbon and Typica are the two major Arabica genotypes grown and both genotypes are found to be susceptible to coffee white stem borer infestation (Bajracharya et al. 2015).

The coffee white stem borer life cycle varies not only with the season but also with the host species (Duport, 1924). Beeson (1941) reported that the shortest life cycle is on non-hosts other than coffee (3.5 to 4 months) and longest on coffee (8 to 11 months). Duport (1924) found that coffee white stem borer completes its life cycle in 3.5 months on teak logs, but the emerging adults are smaller than average size. Also, the borer tunneling in live coffee stem have longer life cycle than in cut stumps (Subramaniam, 1941). Moisture content of host tissue is important factor for the survival of borer larvae (Hanks, 1999).

Emergence of stem borer is also called flight period. The pre monsoon flight begins in April and lasts up to the end of May and the post monsoon flight begins by the end of September and goes up to December in Chikmagalur district, Karnataka, India (Kung, 1977). The highest number of adult beetle emergence occurs in May, June, and July with high temperature. So, the number of beetle emergence varied with prevailing weather factors (Mayne, 1943).

Adult female starts to lay eggs in batches, generally under bark crevices of exposed main stem and thick primaries. The grub enters the stem after feeding in the bark resulting into raised bark which is a sure symptom of coffee white stem borer attack (Rhainds et al., 2002). Extensive damage by larvae may cause wilting, die back or final death of plants (Veeresh, 1995). The adult emerges out by making circular exit holes. Single hole is the sign of one adult emergence (Beeson, 1941). The aim of this study was to make important understanding about the biology of coffee white stem borer, its infestation season and efficient response that can be done in advance for its management.

MATERIALS AND METHODS

Study area

The present study was conducted in Horticulture Research Station, Malepatan, Pokhara, Kaski, Nepal ($28^{O}13'$ N to $83^{O}58'$ E) from January, 2016 to July, 2019. The station lies in the elevation of 838-848 masl. The field experiments were done on the coffee bushes planted with litchi tree; litchi (about 20 years old) -coffee (seven years in 2016) shade system planted at the ratio of 1:4. The coffee plants under observation were managed organically with recommended dose of FYM or poultry manure and mustard oil cake.

Biology study

The biology of coffee white stem borer (*Xylotrechus quadripes* Chevrolat) was studied in laboratory conditions (24-27 ^{0}C, 65-75% RH with natural daylight) in 2016/2017. Initially, five matured stems with 16 cm circumference and 50 cm length (from 9 years old plant) were selected and inoculated each with three newly hatched (first instar) larvae of white stem borer by rupturing the stem. The data on the duration of adult emergence starting from first instar larvae were recorded.

Seasonal abundance

The seasonal abundance of coffee white stem borer was determined by the visual observation of adult emergence holes on the stem in coffee block during 2017 and 2018. A total of 32 matured (8 years) coffee plants of variety Yellow Caturra were taken for the test. We examined all orthotropic stems up to 2m above the collar level of each bush for the borer infestation. One exit hole indicating single adult emergence were counted and marked for the next count to avoid repetition. Counting was done once in a month during mid-day.

The data regarding weather parameters were also recorded for correlation and regression analysis.

Management of coffee white stem borer

The coffee white stem borer management trial was conducted in Horticulture Research Station, Malepatan from April, 2016 to October, 2019. Coffee bushes of seven years old in 2016 were selected from the borer infested orchard. The spacing of coffee bush was 2.5m×2m.

The sample plants were randomly selected with three plants per replication. Each treatment was replicated thrice making altogether nine plants. Sampling was made based on similar level of shade and moisture gradients. By that time, the treatments were applied three times before rainy season (15th April, 15th May, and 15th June); and three times after rainy season (1st September, 1st October and 1st November). The treatments applied were: T1: Root zone application of commercial *Metarrhizium anisopliae* 1×10^8 conidia ml^{-1}@2ml/litre water (cultured in National Entomology Research Center, NARC), T2: Spraying of commercial *Beauveria bassiana* 2.1×10^4 spores/ml @ 5ml/litre water (cultured in National Entomology Research Center, NARC) on main stem and thick primary branches, T3: Spraying of 10% lime on exposed stem and thick primaries, T4: Scrubbing with jute sack and application of red soil mixed with cow dung (1:1) on coffee stem, T5: Scrubbing of main stem and application of Bordeaux paste (10%), and T6: control (no treatment were applied). The scoring scale of 0 to 3 was used for the estimation of degree of borer infestation in different treatments with 0 indicating no damage at all; 1 denoting raised bark on the lower 50 cm of stem; 2 indicating exit holes with the sign of adult emergence; and 3 denoting the wilting of plant and towards death (Thapa & Lantina, 2016). The percentage infestation on each treatment was calculated from the number of infested plants with respect to observed ones.

Statistical analysis

Data on the life cycle of coffee stem borer were analyzed (mean, standard deviation) by using Microsoft excel. The analysis of seasonal availability of the borer was done graphically, plotting the rate of adult emergence (by counting holes) against a sampling date. The monthly minimum and maximum temperature, rainfall and sunshine hours were extracted from the daily data recorded at the weather station of Horticulture Research Station, Malepatan. The additive effect of those weather factors on the abundance of coffee borer has been plotted in the graph. The correlation and regression analysis of weather parameters with coffee stem borer exit holes were done using MS-excel.

RESULTS AND DISCUSSION

Life cycle of coffee white stem borer

The lifecycle study of coffee white stem borer at laboratory condition during 2016/17 revealed that the adult emergence was found at 94±3 days after the inoculation of first instar larva. In field condition, it has been reported that the emergence of adult may take up to 172 days after infestation with egg (Reddy, 2010). Seetharama *et. al.* (2005) reported that coffee white stem borer completes life cycle within 2.5 to 7 months on dried coffee stem.

Abundance of coffee white stem borer

The two year's observation (Fig. 2 and 3) on 32 sample plants of coffee germplasm-Yellow Caturra for the emergence of borer indicated two distinct flight periods in Nepalese arabica coffee; one during April - June (summer flight or pre monsoon emergence) and another during September - November (autumn flight or post monsoon emergence). The first year (2017) result showed more adult emergence from March to July with major peak at the month of June (total of 16 exit holes) and September to November with the peak of September (10 exit holes). Likewise, during second year (2018), pre-monsoon emergence started from March and ended with peak emergence in June (8 exit holes) and post-monsoon emergence started from the second fortnight of August to November with the peak emergence in the month in October (14 exit holes).

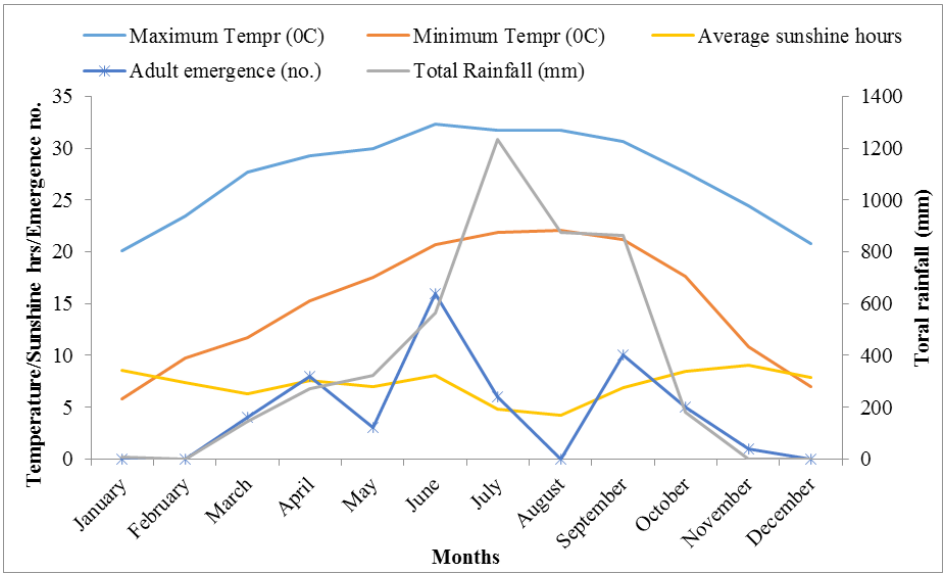

Figure 2. Effect of weather parameters on coffee white stem borer adult emergence, 2017

No adult emergence was found during extreme cold season and rainier days i.e. December- February and July- August, while maximum emergence was found during hot and more sunshine days. Similar results were found in India with one pre-monsoon flight and another post monsoon flight (Subramaniam, 1934). A small number of adults also emerged before and after these flight periods (Reddy & Bhat, 1987). In China, coffee white stem borer has three peak emergence periods per year i.e. in May, October and December (Reddy & Bhat, 1987; You Sheng et al., 2002). In Vietnam, the three peak emergence periods are May-July, November-December and February-March) (Caresche, 1938). This result revealed that the adult emergence is highly correlated with season and weather parameters.

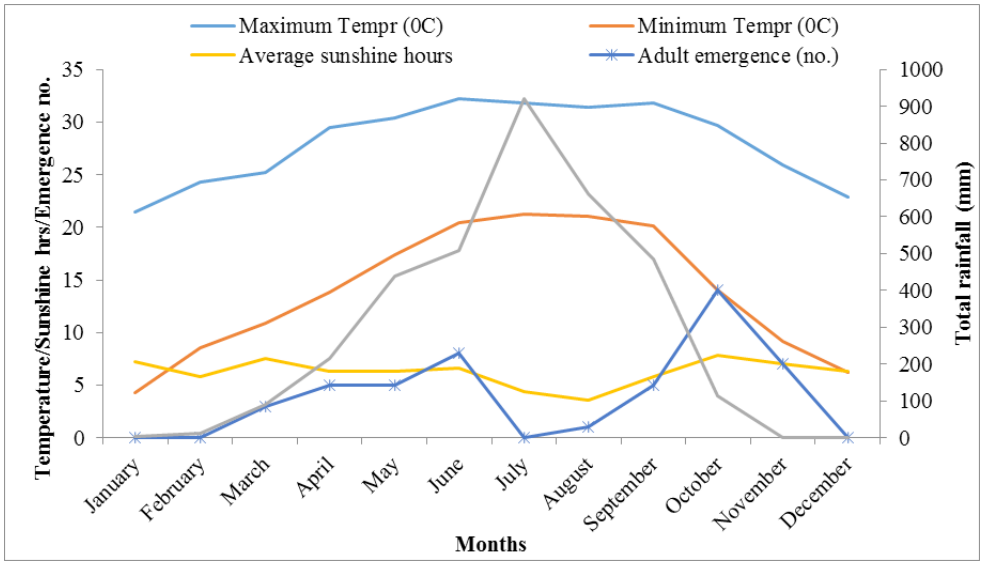

Figure 3. Effect of weather parameters on coffee white stem borer adult emergence, 2018

The weather data of the study location was found significantly correlated with the coffee white stem borer adult emergence (Table 1). Maximum temperature and average sunshine hours showed significant positive correlation in subsequent years 2017 and 2018, while rainfall correlated significantly positive in 2017 (r = 0.43) and negatively during the year 2018 (r = -0.1). Negative correlation during second year might be due to heavy rains (920.6mm) with low sunshine hours (4.37), while positive correlation would be due to well distributed showers with sunnier days. Up to certain level, wet months coupled with warm temperature seems favorable for the adult borer emergence and breeding, while in contrary the cold temperature disrupted developmental process and adult emergence. These findings were in line with Kutywayo et.al., (2013) who observed that the coffee white stem borer in Zimbabwe corresponds with rainfall and warm weather. Subramaniam (1934) also reported that environmental temperature and moisture content of plant play an important role in the larval development of stem borer leading to emergence of beetles at different interval.

Table 1. Correlation coefficients (r values) of coffee white stem borer adult emergence with weather parameters

Year\Weather parameters	Maximum Temp (°C)	Minimum Temp (°C)	Total Rainfall (mm)	Average sunshine hours
2017	0.66*	0.59^{NS}	0.43*	0.06*
2018	0.41*	0.22^{NS}	-0.1^{NS}	0.53*

NS-Non significant (p≥0.05), Significant (p<0.05)

The multiple regression results showed the significant response (P<0.05) of coffee white stem borer emergence to weather parameters (Table 2 and 3). In the year 2017, maximum temperature, minimum temperature and rainfall individually contributed 51 %, 42 % and 22 %, respectively to adult borer emergence while average sunshine hour was responsible only 0.4 % in determining the insect emergence. However, during 2018, the maximum temperature, minimum temperature and rainfall individually contributed 18 %, 5.8 % and 2%, respectively to adult emergence and average sunshine hour had the highest contribution (31.8 %) for determining the insect emergence. This much difference in effect of weather factors, especially of sunshine duration, might be due to other climatic factors like light intensity or combined effect of temperature, rainfall and sunshine hours in the insect development.

Table 2. Multiple regression models summary output for coffee white stem borer, 2017

Parameters	Coefficient	Standard error	R^2	P value
Intercept	-64.46	14.08		0.003
Maximum Tempr (°C)	2.04	0.65	0.51	0.016
Minimum Tempr (°C)	-1.13	0.59	0.42	0.094
Total Rainfall (mm)	0.01	0.005	0.22	0.046
Average sunshine hours	3.56	0.83	0.004	0.004
Overall		2.43	0.85	0.0054

Y- Coffee white stem borer adult emergence; X_1- Maximum Temp (°C); X_2- Minimum Temp (0C); X_3- Total Rainfall (mm); X_4- Average sunshine hours

Table 3. Multiple regression models summary output for coffee white stem borer, 2018

Parameters	Coefficient	Standard error	R^2	P value
Intercept	-53.13	13.20		0.005
Maximum Tempr (0C)	1.94	0.76	0.18	0.039
Minimum Tempr (0C)	-0.47	0.64	0.058	0.484
Total Rainfall (mm)	0.007	0.006	0.012	0.232
Average sunshine hours	1.84	0.69	0.318	0.033
Overall		1.71	0.898	0.0014

Y- Coffee white stem borer adult emergence; X_1- Maximum Temp (0C); X_2- Minimum Temp (0C); X_3- Total Rainfall (mm); X_4- Average sunshine hours

Evaluation of different management practices for coffee white stem borer

The bar graph (Fig. 4) elucidates that among the six treatments evaluated for coffee white stem borer management, lowest level of infestation (11.11%) was found in the treatment with scrubbing of stem and application of red soil mixed with fresh cow dung and scrubbing of stem and application of Bordeaux paste, separately. The second effective (only 22.22 % infestation) treatments were found to be the root zone application of *Metarrhizium anisopliae*, spraying of *Beauveria bassiana*, and spraying of 10 % lime on main stem and thick primaries, separately. While, highest level of infestation (44.44 %) was found in control. Bhat et al. (1992) reported that smoothening of stem before flight period prevents the egg laying of coffee borer and decrease borer infestation. Also, Vinod Kumar *et al*. (2009) reported that the lime (10%) application on the stem provides some protection against the coffee white stem borer in the field as it fills the crevices on the stem and thus prevents the beetles from egg deposition. Use of *Beauveria bassiana* with a CFU count of 2×10^8 per ml in field condition was recommended by Manikandan et al. (2019) with the larval mortality of 40-50 %.

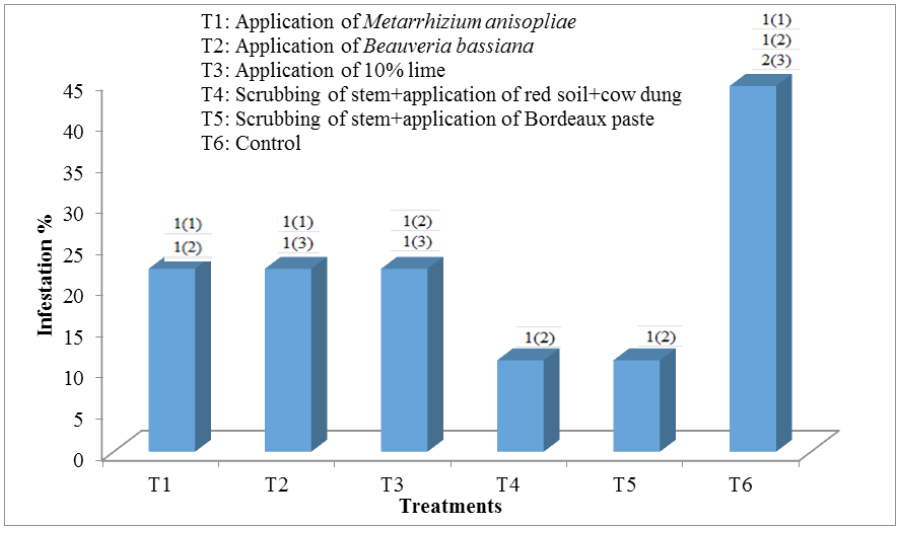

Figure 4. Evaluation of different management practices for coffee white stem borer in Horticulture Research Station, Malepatan, 2016-2019

1-raised bark on stem, 2- adult emergence holes and 3-plant wilting and towards death

Note: The number above the bar is number of infested plant per 9 sample plant; the number inside bracket is level of damage

CONCLUSION

In laboratory condition, coffee white stem borer completed its life cycle in 94±3 days from first instar larvae. Observations on the monthly emergence pattern of adult beetles revealed that the stem borer abundance is highly weather dependent and found two peak emergence periods in a year during April-June and September-November. The management options revealed that 44.44% infestation in control plot can be reduced to 11.11 % with smoothening of stem by scrubbing and application of red soil mixed with fresh cow dung or stem scrubbing and application of Bordeaux paste on it. While with root zone application of *Metarrhizium anisopliae* or *Beauveria bassiana* or spraying of 10 % lime on main stem and thick primaries reduce infestation to 22.22 %. Based on the findings, stem scrubbing and application of red soil mixed with fresh cow dung or scrubbing of stem and application of Bordeaux paste (10%) for the effective management of coffee white stem borer infestation during major adult emergence periods in April-June and September–November, is recommended.

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