Research Article

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Assessment of crop loss in Arabica coffee due to white stem borer, *Xylotrechus quadripes* Chevrolat (Coleoptera: Cerambycidae) infestation

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Abstract

The coffee white stem borer (CWSB) is the most dreaded pest of Arabica coffee in India. Due to the concealed nature of this pest, the management measures are difficult and require the timely implementation of control measures.The recommended practices for the management of CWSB mainly targets on eggs and early instar larvae, apart from tracing and uprooting of infested plants before the commencement of flight periods (April-May and Oct-Dec). In general, young Arabica coffee plants infested by CWSB die within a year, whereas aged plants withstand the attack for few more years. However, such plants become less productive, susceptible to diseases and also serve as inoculum for further spreading of the infestation. A study was undertaken to assess the crop loss due to CWSB infestation on established Arabica plantation in Tamil Nadu. The result indicated a significant difference between healthy and infested plants and the crop loss was to the tune of 17.7 per cent. Further, quantitative data on out-turn percentages recorded at different stages of coffee processing (right from harvesting of fruits to marketable green coffee bean) are discussed in this paper.

Keywords: Coffee, crop loss, out turn, *Xylotrechus quadripes*, yield

Introduction

The coffee white stem borer (CWSB), *Xylotrechus quadripes* Chevrolat (Coleoptera: Cerambycidae), is the most dreaded pest of Arabica coffee in India and endemic to Indo-China region. Except for India, all other countries like Vietnam, Thailand, and Indonesia are primarily producing Robusta coffee which is resistant to this pest (Seetharama *et al.*, 2005). Thus, India is the only country where the CWSB is prevalent among the coffee-producing countries in the Asia-Oceanic region. The female beetle of CWSB lays eggs on the surface of the coffee stem. After hatching, the larvae enter inside the main stem and make tunnels in all the directions. In some cases, the tunnels may extend up to the root region. The larval stage lasts for about ten months, followed by the pupal stage for about one month and after which the adult beetle emerges out of the stem and carries forward further generations and infestation. There are two flight periods for the CWSB in a year: the summer flight from April to May and the winter flight from October to December. Affected plants show externally visible symptoms such as ridges on the stem, wilting and yellowing of leaves. Due to the concealed nature of the life cycle, the management measures are difficult and highly time-specific. The major management practices for the control of CWSB include targeting eggs and the early instar larvae, besides tracing and uprooting of infested plants before the commencement of the flight period. Less than five plants infested per acre is considered as low level of infestation. Whereas, ten to fifteen and above fifteen infested plants per acre are considered as the medium and high level of infestation, respectively. Normally, the young plants infested by CWSB succumb within a year and aged

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plants withstand the attack for few more seasons. In the coffee tracts of Karnataka, severely affected plants are uprooted. On the contrary, in the coffee tracts of Tamil Nadu like Yercaud and Pulneys, the CWSB infested plants survive for a longer period. However, such plants become less productive, yielding more of under-developed fruits (commonly known as floats/jollu), susceptible to diseases and serve as inoculum for further spread of infestation onto the healthy plants.

Several reports are available on biology as well as IPM of CWSB in coffee. However, reports on crop loss due to CWSB infestation are very limited in coffee (Veeresh, 1995; Samuel *et al.*, 2013). Crop loss due to pests and diseases are major threats to the income and food security of thousands of rural families world-wide. The assessment of crop loss (yield and economic losses) and identification of causes for the yield loss are imperative to improve the production potential of any agro-ecosystem. Assessment of crop loss and efforts to quantify it in perennial crops are still scant (Cheatham *et al.*, 2009; Savary and Willocquet, 2014; Avelino *et al.*, 2015). As India is a major producer of Arabica coffee in the Asia-Oceanic region, the economic importance of the CWSB is very significant (Machia, 1999). Thus, the present study was undertaken to estimate the crop loss due to CWSB infestation and to generate data on the impact of CWSB infestation on out-turn percentage at different stages of coffee processing and raw quality of the coffee bean.

Materials and methods

In general, yield loss due to pest and disease infestation is estimated by comparing the yield level of healthy and infested plants and the number of plants uprooted per unit area. Quantification of yield losses in a perennial crop like coffee is particularly complex because of the typical biennial pattern of production: high production in one year followed by low production in the succeeding year (Da Matta *et al.*, 2007, Smith and Samach, 2013). Hence, the crop loss due to CWSB infestation was assessed consecutively for three years in a private estate at Yercaud, Tamil Nadu from 2015 to 2017 to obtain average yield loss. To estimate the crop loss, fifty plants each of healthy and CWSB infested plants (same age group of Chandragiri variety) were selected for the study. The selected plants were marked appropriately and all the agronomic practices were followed, as per the recommendation except insecticide application. Infested plants were kept free from insecticide applications and subjected to the natural infestation of the CWSB. Whereas, healthy plants were treated with recommended insecticide to keep the plants free from CWSB infestation. Every year, fruits from fifty CWSB infested and healthy plants were harvested separately and pooled to get the total fruit yield. The harvested fruits were subjected to post-harvest processes, as detailed in Coffee Guide (Anonymous, 2014). The quantitative data on total yield, weight of floats/jollu, and clean coffee were recorded after pulping of coffee fruits. In addition, the weight of 100-coffee beans was weighed using a sensitive electronic balance (Shimadzu TXB622L) at 10 per cent standard moisture level determined by a calibrated moisture meter. The data on total fruit yield and other quantitative parameters recorded for three years from 2015 to 2017 on healthy and infested plants were analyzed by paired t-Test using the statistical software SPSS (Version 10).

Results and discussion

Year-wise data on the total fruit yield (from fifty plants) and out-turn percentages recorded at different stages of coffee processing from healthy and CWSB infested plants are presented in Table 1. The data indicated that significant differences were noticed between healthy and CWSB infested plants with respect to all the parameters studied.

The differences in total fruit yield between healthy and infested plants ranged from 10.6 to 23.7 per cent with an overall average of 16.9 per cent. The highest percentage reduction of total fruit yield between healthy and CWSB infested plants was observed in 2015 (23.7%) followed by 16.5 per cent in 2017 and least was recorded in 2016 (10.6%) confirming the reduction of total fruit yield due to CWSB infestation. This data was in agreement with the previous report by Samuel *et al.* (2013). He reported 33.2 to 41.6 per cent reduced fruit yield in CWSB infested plants compared to healthy plants of Arabica selections like Sln. 3 (S.795) and Sln. 12 (Cauvery). Veeresh (1995) also reported yield reduction from 2 to 20 per cent due to CWSB infestation in Arabica coffee.

Table 1. Effect of CWSB infestation on fruit yield and out turn percentage of coffee

Parameters	2015		Difference	2016		Difference	2017		Difference
	H	I	(%)	H	I	(%)	H	I	(%)
Fruit wt. (kg)	97.0	74.0	23.7	70.5	63.0	10.6	69.5	58.0	16.5
Floats (kg)	2.1 (2.1)	4.1 (5.4)	3.4	0.8 (1.1)	4.2 (6.7)	5.6	0.7 (1.0)	4.0 (6.9)	5.8
Clean coffee (kg)	17.6 (87.7)	12.0 (81.9)	5.7	10.6 (74.9)	8.2 (72.7)	2.2	10.5 (75.2)	7.4 (72.5)	2.7
Fruit to clean coffee ratio	5.5	6.2	0.7	6.6	8.7	1.1	6.2	7.5	1.3
100 bean weight (g)	19.0	17.0	10.5	18.0	15.0	16.7	18.0	16.0	11.1
No of fruits kg^{-1}	445	471	5.5	410	475	13.7	441	463	475

H- Healthy, I- Infested. Values in the parenthesis represents the percentage conversion from the previous process

Floats (or) floaters (commonly known as jollu) are those coffee fruits which float on water. Floats comprise of over-ripe fruits, tree-dried fruits, fruit with single bean, disease and pest infested fruits and under-developed fruits. Several factors are known to increase the production of floats: soil moisture, nutrients status in the soil and pest and disease incidence. CWSB infested plants produces more floats, as CWSB beetle damages the phloem tissue which supply nutrients to the plants from soil. Floats invariably contain one healthy and one under-developed coffee bean and sometimes two under-developed coffee beans. Thus, excess presence of floats in the harvested coffee lot has significant influence on the final output of coffee bean sample (Gopinandhan *et al.*, 2018). In the present study, data on floats percentage were recorded on healthy and CWSB infested plants across the years. The float percentage on healthy plants ranged from 1.0 to 2.1 (average -1.4) and 5.4 to 6.9 (average - 6.3) in infested plants. The mean difference in the float percentage between the healthy and infested plants recorded was 4. 9.

With regard to the data on fruit to clean coffee ratio (which is very critical for out-turn percentage of coffee samples) indicated that in case of healthy plants, the fruit to clean coffee ratio ranged from 5.5 to 6.6 with an average of 6.1. While, in case of infested plants, the fruit to clean coffee ratio ranged from 6.2 to 8.7 with an average of 7.5. The recommended fruit to clean coffee ratio for Arabica coffee is 5.5 (*ie.,* 5.5 kg of coffee fruits yields 1 kg of clean coffee). Thus, the difference in fruit to clean coffee ratio between healthy and CWSB infested was to the tune of 1.4. It was also observed that even in case of healthy plants, the fruit to clean coffee ratio kept increasing across the years and this may be due to several reasons like inadequate supply of farm inputs and other environmental factors.

As far as coffee is concerned, the term quality refers to physical characteristics such as shape, color and weight of coffee beans as well as organoleptic attributes like acidity, aroma and flavor (Giomo *et al*., 2012). Coffee plants grown at higher altitude (above 3,000 feet) produces denser beans due to slow maturation of coffee fruits, as compared to coffee beans obtained from lower elevation. It is customary in coffee research programme, to record 100-coffee bean weight to assess the raw quality of coffee bean and it is expressed as gram per 100-coffee bean weight. Coffee cultivar with higher 100-coffee bean weight is preferred and such coffees attracts premium price in the international market. Several factors attribute to the reduction of bean weight which include pest and disease infestations also. In the present investigation, data on 100 bean weight recorded in healthy and CWSB infested plants revealed that 100 bean weight was comparatively better in healthy plants (ranged from 18 to 19 gram) than in CWSB infested plants (15 to 17 gram). The reduction of 100-coffee bean weight in case of CWSB infested plants was due to the damages in the phloem tissue caused by CWSB, which obstruct the flow of nutrients from soil (Gopinandhan *et al*., 2018).

The number of fruits per kg was more in the infested plants, as compared to healthy plants indicating the white stem borer infestation reduces the fruit weight resulting in increased number of fruits in one kg fruits harvested. This will directly affect the out-turn ratio.

Statistical analysis of data on total fruit yield and quantitative parameters indicated that significant differences between healthy and infested plants in all the parameters studied and presented in Table 2.

Venkatesha and Dinesha (2012) reported that an annual loss of $17.5-26.0 million due to CWSB infestation in India. Further, Sreedharan (2002) documented that if ten plants per ha are lost due to CWSB infestation, then about 773 hectares of Arabica area will be lost on the basis of total land area occupied by Arabica coffee. Economic losses caused by uprooting of CWSB at the rate of one plant per ha result in a total loss of about US $642,585 annually in India (Radhakrishnan *et al*., 1987; Naidu, 1997). In India, over nine million trees are destroyed each year due to CWSB infestation, costing around $40 million annually for replacement and loss in production (Hall *et al*., 2006). Barbosa *et al*., 2004 reported 13 to 45 per cent yield losses in coffee due to a nematode, *Meloidogyne exigua* in Brazil.

In Tamil Nadu, though the damage of Arabica plants due to CWSB infestation is less compared to Karnataka, the yield loss is considerable when the borer affected plants were retained in the field. The results of the present study showed a considerable yield loss (17.72%) in CWSB infested plants. Taking into account of this result, it works out to be a yield loss of approximately 336 kg of fruits (when fifty plants are infested with CWSB). Thus, maintaining CWSB infested plants will lead to crop loss and also results in the production of coffee beans with inferior quality.

The most observable difference among the variables during the study period was recorded in 2015, where the coffee yields and post-harvest data were noticeably higher compared to 2016, illustrating the biennial behavior of coffee production. In coffee, the yield loss of a particular year depends on the effect of last year. The CWSB attack arrests the nutrient flow to the plant and affects the formation of bearing wood/branches for the next year. Therefore, the study has been carried out for three years continuously on the marked plants to measure the exact crop loss caused by CWSB. In general, yield loss is assessed in the current year, and therefore we assumed that it was primary yield loss. The range of this primary yield loss is wide, depending on the type of crop/variety and nature of pests and diseases. However, farmers who cultivate annual crops, normally choose the best and healthiest seeds, follow crop rotation practices (or) sometimes disinfect soil before sowing; therefore, expected secondary losses used to be quite low. On the contrary, in perennial crops like coffee, secondary yield loss, resulting from damages of the previous year, cannot be avoided. Losses over several consecutive years are even expected, which can only be reduced by

Table 2. Mean data on comparative crop losses due to CWSB infestation

Parameters	Healthy plants	Infested plants	Percentage difference	t-calculated value
Fruits (kg)	79.0	65.0	17.7	3.0*
Floats (%)	1.4	6.3	4.9	1.3*
Clean coffee (kg)	12.9	9.2	28.9	3.8*
Fruit to CC ratio	6.1	7.5	1.4	16.9*
Bean weight of 100 beans (g)	18.3	16.0	12.7	7.0*
Number of fruits kg^{-1}	432.0	469.7	8.7	2.7*

*The t-value significant at P=0.05

implementing appropriate agronomic practices to recover plant growth (Cerda *et al*., 2017).

Thus, timely control measures need to be taken to manage CWSB. In conclusion, there was a marked difference in terms of yield and outturn in CWSB infested plants compared to healthy plants. This study recommends, not to keep the CWSB infested plants for the sake of meager quantity of yield, which not only affects the out-turn percentage of coffee and also spread the infestation further to the healthy plants.

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