Research Journal of Agricultural Sciences
An International Journal

Res. Jr. of Agril. Sci. **12**(2): 552–555

P- ISSN: 0976-1675 | **E**- ISSN: 2249-4538

www.rjas.org

Research Paper

Factors Impacting the Incidence of White Stem Borer (*Xylotrechus quadripes*) in Arabica Coffee Plantations of Western Ghats: A Case of Kodagu District, Karnataka State, India

Gana Shruthy M. K.*[1]

Received: 20 Jan 2021 | Revised accepted: 24 Mar 2021 | Published online: 25 Mar 2021

A B S T R A C T

Taking into account White Stem Borer (WSB) as a major limiting factor for Arabica coffee production, the paper analyses several factors impacting uprooting of Arabica due to WSB. The study was conducted in Kodagu district of Karnataka state, based on both qualitative and quantitative data collected from 60 Arabica growers during March-July 2017. The uprooting of Arabica trees due to White Stem Borer was regressed on elevation of estates (m.a.s.l), shade trees per ha (number), age of Arabica trees (years), area under coffee cultivation (ha), rainfall (mm), and expenditure on pesticides (Rs). The analyses found that the elevation of estates, indigenous shade trees and pesticides negatively influenced incidence of borer attack. The WSB incidence was higher in Arabica with the age group between 20-30 years, while lower in older trees above 30 years. Interestingly our studies reveal that uprooting was not affected by area (ha) and rainfall (mm). The study suggests cultivation of Arabica in higher altitudes, retaining traditional agro-forestry system, extension and education activities related to age structure of coffee trees and inter-country partnership research on WSB.

***Key words*:** Arabica coffee, White stem borer, Elevation, Shade trees, Pesticides, Rainfall

Coffee is an important commodity of trade and value. India earned a revenue of ₹5199 crore from its exports during 2019-20, besides creating employment opportunities and raising livelihoods of coffee growers [1]. Coffee is predominantly grown in the ecologically sensitive Western and Eastern Ghats of India adding much to the rich biodiversity of the country. Commercially, there are two major varieties of coffee viz., Robusta (*Coffea canephora)* and Arabica (*Coffea arabica*). Factually, the Arabica variety of coffee is considered to be superior to Robusta variety owing to its lower caffeine content (0.9 to 1.7 per cent), finer cup qualities and exclusively used for all specialty coffees. Nonetheless, the price of Arabica is about 2.19 times higher than Robusta. However, over the recent years there has been a radical structural shift from superior quality Arabica to inferior quality Robusta owing to White Stem Borer (*Xylotrechus quadripes*), the most dreaded pest in Arabica and a major reason for productivity decline in Arabica [2]. The heavy infestation of White Stem Borer (WSB) in Arabica plantations with resultant uprooting of Arabica trees and heavy crop losses have prompted Arabica growers to shift towards Robusta cultivation. Likewise, [3] ranked White Stem Borer as a major production constraint in Arabica cultivation and a major cause for productivity decline. The dimension of shift is to such an extent that the coffee sector fears high risk of extinction of Arabica coffee in the near future.

Currently, though the White Stem Borer is a single largest productivity constraint in Arabica affecting both quality and quantity, surprisingly there has been vary less studies on this aspect. For instance, the earlier studies by [4] analyzed the socio-economic status of smallholder coffee farms with reference to integrated stem management of WSB. While, [5] reported on Integrated Stem Borer Management in smallholder coffee farms in India, Malawi and Zimbabwe. Further, [6] studied on bio-ecology and management of White Stem Borer. Meanwhile, [7] studied the occurrences of WSB and causes for shift from Arabica to Robusta variety of coffee in Kodagu. However, the earlier studies have not taken into account the majors factors impacting the incidence of White Stem Borer in terms of uprooting of Arabica trees. Thereby, the current study identifies several factors and attempts to understand its impact on the incidence of Borer attack in Arabica.

Further, the study seeks to promote and safeguard Arabica coffee plantations in India by providing the policy makers with vital factors that could limit Arabica cultivation in India, so as to eliminate or minimize the limiting factors. As John Von Liebig in his ‘Law of Minimum’ stated that it was only through improvement of ‘limiting factor’ higher productivity could be realized [8]. In a similar vein, we consider White Stem Borer as the ‘most’ limiting factor adversely affecting coffee productivity [9]. The study also assumes importance in the current context of ongoing

*Gana Shruthy M. K.
ganashruthy@gmail.com

[1]Department of Economics, Government First Grade College for Women, Vijayanagara, Mysore - 570 032, Karnataka, India

nationwide discussion on how to reduce White Stem Borer (WSB) in Arabica, safeguard and enhance Arabica productivity in India [10]. The study would provide stakeholders with necessary inputs to frame 'location specific policies and boost Arabica production as targeted by the Coffee Board. By doing so the study intends to enhance coffee growers' income and improve their livelihoods.

MATERIALS AND METHODS

The present study was conducted in Kodagu district of Karnataka state as it stands first in the country in terms of both area and production of coffee. The district alone contributes for 38 per cent of coffee production in the country. The survey respondents were identified through multi-stage stratified random sampling method based on the latest official records of Coffee Board and Codagu Planters' Association (CPA), Madikeri. At the first stage, three Arabica liaison zones were selected. At the second stage of sampling, 2 villages from the liaison zone were selected. At the third stage, 10 Arabica growers were randomly selected from each of these villages. The total sample size used for this study was 60 households. The survey employed both qualitative and quantitative data collected between March-July, 2017. The data pertains to the reference period of 2016-17 agricultural year. A semi-structured pre-tested questionnaire was prepared and pre-tested. The secondary data pertaining to the study was collected from publications of Indian Coffee Board and earlier literature in the area. The multiple regression analysis was used to analyze the impact of several factors on incidence of White Stem Borer in terms of uprooting of Arabica trees per ha.

Multiple regression analysis

The incidence of White Stem Borer in terms of number of Arabica trees uprooted per ha was regressed against elevation of estates (m.a.s.l), shade trees per ha, expenditure on pesticides (Rs/ha), actual rainfall (mm) and area under coffee (ha).

The functional form of the model is given as:

$$\text{Ln (Number of trees uprooted)} = \alpha_0 + \beta_1 \text{Ln (elevation)} + \beta_2 \text{Ln (shade trees per ha)} + \beta_3 \text{Ln (expenditure on pesticides)} + \beta_4 \text{Ln (actual rainfall)} + \beta_5 \text{ Ln (area under coffee)} + \beta_6 d_1 + \beta_7 d_2 + e$$

Where,

α is constant or intercept

$d_1 = 1$, if Arabica tree age is 20 to 30 years, 0 otherwise

$d_2 = 1$, if Arabica tree age is more than 30 years, 0 otherwise

e is the unexplained error term

RESULTS AND DISCUSSION

The uprooting of Arabica trees due to White Stem Borer (WSB) was regressed on elevation (meters above mean sea level), age of Arabica trees (years), area under coffee (ha), rainfall (mm), shade trees per ha (number) and expenditure on pesticides (Rs/ha). The results are provided in (Table 1).

Elevation of coffee estates

The inclusion of elevation was intended to capture whether or not the probability of uprooting was more in estates located at higher altitudes or the ones located at lower altitudes. Our studies reveal that the elevation of coffee estates negatively influenced the uprooting of Arabica trees due to White Stem Borer (-8.36) (Table 1). Contrastingly, the incidence was found to be lower in estates located at a higher elevation. Likewise, [11] documented that the incidence of WSB decreased with the increase in elevation and that the highest incidence were identified in the estates located below 1036 m.a.s.l. The higher elevation estates are characterized by low temperature and heavy rains that control the breeding of White Stem Borer. However, the lower elevation estates experience erratic rainfall and increased temperature that provide congenial conditions for breeding of borer [12].

Shade trees in coffee estates

The shade trees were highly recommended by the Coffee Board to control White Stem Borer. Now to what extent the shade trees control the White Stem Borer was the key question we intend to answer. For this, the number of shade trees per ha in the Arabica estates were taken into account. Our studies reveal that the incidence of WSB decreased with the increase in the number of shade trees per ha. For every 1 per cent increase in the number of shade trees, the uprooting of Arabica decreased by 0.40 per cent (Table 1).

The Arabica growers in Kodagu adopted two tier mixed shade pattern in their estates, with Dadap (*Erythrina lithosperma*) as a lower canopy of shade and the permanent trees like timber species (*Dalbergia latifolia*), Jack fruit (*Artocarpus integrifolia*), Mahagony (*Cedrela toona*). These shade trees do not harbor the WSB [13] and thereby the estates with more number of shade trees were less prone to borer attack. While [14] noted that incidence of borer was lower in estates that comprised of higher number of shade trees particularly dadaps. However, the exotic silver oaks (*Grevilia robusta*) positively influenced the borer attack in Arabica. The canopy of indigenous shade trees with higher foliage cover provided optimum shade in coffee estates thereby lowering the surrounding temperature. This reduced temperature constrained the borer breeding in Arabica estates, henceforth reducing incidence of borer attack in estates that comprised of higher shade cover [15].

Pesticides spray in Arabica

The spraying of pesticides (Chlorpyrifos, Lindane and Contof) was a major production practice followed by the coffee growers to control White Stem Borer in Kodagu. However, during our field survey, the growers expressed that the use of chemical pesticides did not help them control the borer. About 24 per cent of the surveyed growers opined that pesticides were ineffective in control of borer [16]. Now does the spraying of pesticides actually help the growers to control the incidence of White Stem Borer was the key question we attempt to answer. Thereby, the expenses incurred on pesticides were included in the model. The associated co-efficient was found to be negative (-0.51) and significant at 5 per cent (Table 1). Thus, the expenses on pesticides (Chlorpyrifos, Lindane, Contof) reduced the incidence of WSB in individual estates. These results were in contrast to the growers' belief that the use of chemical pesticides did not help them to control the borer attack. However, the growers were compelled to adopt limited application of Lindane owing to stringent control over minimal residual Lindane application by coffee importing countries [17]. However, these chemicals could leave toxic impact on environment.

Age of Arabica trees

The age of coffee trees impact it's productivity. Now, the major question was to determine whether there exists any relationship between different 'age of group' and incidence of

White Stem Borer. Thereby, the study takes into account age of Arabica trees and attempts to understand it's impact on borer attack.

In order to assess the impact of incidence of White Stem Borer on physiological age of Arabica trees, we added three dummy variables as a categorical predictor viz., Dummy variable 1 = age of plants ≤ 20 years, Dummy variable 2 = age of plants between 20-30 years and Dummy variable 3 = age of plants >30 years.

The result revealed that the incidence of White Stem Borer was higher in plants with the age group between 20-30 years, while incidence lowered in older trees above 30 years of age (Table 1). Likewise, the younger Arabica plants of 4-5 years old that have just entered the bearing period are heavily attacked by the borer. The older trees (> 30 years) are inclined to live with borer attacks and manifest the signs of borer attack only under the moisture or bearing stress.

Generally, the old estates under good agronomic practices could easily sustain borer attack with adverse impact on yield [18]. In case of young plants, the larva bores into the stem resulting in the death of young plants. Though the older Arabica plants survive the borer attack, there has been profound reduction in yield and they were more susceptible to diseases. Contrastingly, studies have also indicated borer incidence was high in older plants (8.3 percent) and incidence of only 0.7 per cent in very young plants [19].

Table 1 Factors affecting incidence of WSB in Arabica (uprooted trees per ha)

Variable	Coefficient	't' value	Level of significance
Constant	80.124	-8.9***	0.00
Ln elevation (m.a.s.l)	-8.365	-6.7***	0.00
Ln shade trees (number per ha)	-0.409	-2.3**	0.03
Ln expenditure on pesticides (Rs/ha)	-0.511	-2.2**	0.03
Dummy on age of plant (20-30 years)	-0.068	-0.4	0.66
Dummy age of plant (≥ 30 years)	-0.431	-2.2**	0.03
Ln Actual rainfall (mm)	-0.395	-1.6	0.11
Ln area under coffee (ha)	0.04	-0.7	0.50
R Square	0.71		
F	21.13***		
Number of observations	60		

*** and **Significant at 0.01 and 0.05 level respectively

Area under Arabica cultivation

The area under coffee (ha) was taken into account to understand if the incidence of White Stem Borer (WSB) was more severe on small or large sized holdings. However, the co-efficient associated with area under coffee (ha) was found to be insignificant in the model [20].

Average annual rainfall in coffee estates

Given the wide variation in rainfall distribution among the surveyed estates, the annual rainfall (mm) factor was also included in the model to understand the influence of rainfall on uprooting of Arabica due to White Stem Borer. However, co-efficient associated with average annual rainfall (mm) was found to be insignificant in the model [21].

Policy implications

In Kodagu, many growers ventured into coffee plantations post liberalization period only after higher prices in coffee were realized. During that period, new Arabica plantations were established particularly in lower elevations and marginal areas characterized by higher temperature that were highly uncongenial for Arabica cultivation. Nevertheless, our studies reveal that White Stem Borer attack was more severe in estates located at lower altitudes. Henceforth, the institutions must encourage Arabica cultivation at higher altitudes characterized by lower temperature and higher shade cover [22].

Owing to commercialization of coffee estates, the growers were replacing indigenous shade trees with exotic silver oaks (*Grevilia robusta*) owing to its higher timber value [23]. These silver oaks must be discouraged in the coffee estates. While, the institutions must in-sensitize the growers to retain traditional coffee agro-forestry system with native shade tree cover. This goes in liu with the NITI Aayog that underlies inclusiveness of significant number of shade trees with plantation crops and maintenance of agro-forestry system within the coffee plantations. To do this, the growers must be supplied with indigenous shade trees in tie up with the forest department. Further, bio-pesticides to be encouraged [24].

The younger estates (20-30 years) at the prime stage of production are highly susceptible for borer attack. Thereby, extension and education activities should be conducted on 'age structure of coffee trees and its impact on productivity and incidence of White Stem Borer' [25].

Lastly, inter-country partnership for conducting research on White Stem Borer, understanding biological conditions of the borer in relation to agro-climatic zones of the coffee estates is important, rather than any isolated coffee research.

CONCLUSIONS

The present study reveals several factors impacting the uprooting of Arabica trees due to white stem borer. The study concludes that the elevation of Arabica estates had a major impact on the incidence of White Stem Borer. The Arabica estates located at higher elevation were less susceptible to borer attack. Likewise, the higher number of indigenous shade trees in coffee estates reduced the incidence of borer attack. In contrast to the growers' belief, chemical pesticides did have a positive impact on controlling the pest. Interestingly, the Arabica plants in the age group between 20-30 years were found to be highly susceptible to borer attack. While the older plants above 30 years were resistant and survived pest attack. The average annual rainfall and area under Arabica cultivation were found to be insignificant in the model.

LITERATURE CITED

1. Anonymous. 2020. Indian Coffee Board. *Database on Coffee*, September 2020. www.indiacoffee.org
2. Gana Shruthy MK. 2016. White Stem Borer (WSB) in Western Ghats and shifts towards Robusta coffee: Evidences from a recent household survey of Arabic coffee growers in Kodagu district of Karnataka. *Agricultural Situation in India* 73(7): 26-37.
3. Murphy TS, Phiri NA, Sreedharan K, Kutywayo D, Chanika C. 2008. Integrated stem borer management in smallholder coffee farms in India, Malawi and Zimbabwe: *Final Technical Report*, CFC/CABI/ICO/CRS/CB.
4. Basavaraj MC, Sreedharan K, Vinod KP, Murphy ST, Naidu R. 2005. Socio-economic analysis of smallholder coffee farms with reference to integrated management of white stem borer in Karnataka, India. *Proceedings of the ASIC 2004 20th International Conference on Coffee Science*, Bangalore, 11–15 October 2004.
5. Bote AD, Struik PC. 2011. Effects of shade on growth, production and quality of coffee (*Coffea arabica*) in Ethiopia. *Journal of Horticulture* 3: 336-341.
6. Venkatesha MG, Dinesh AS. 2012. The coffee White Stem Borer *Xylotrechus quadripes* (Coleoptera: Cerambycidae): bioecology, status and management. *International Journal of Tropical Insect Science* 32(4): 177-188.
7. Davis AP, Gole TW, Baena S, Moat J. 2012. The impact of cli-mate change on indigenous arabica coffee (*Coffea arabica*): Predicting future trends and identifying priori-ties. *Public Library of Science (PLoS) One* 7(11): 1-13.
8. Liebig JV. 1855. Principles of Agricultural Chemistry: With special reference to the Late Researchers Made in England, London: Walton and Maberly.
9. Dhanya B, Sathish BN, Viswanath S, Purushothaman S. 2014. Ecosystem services of native trees: experiences from two traditional agroforestry systems in Karnataka, Southern India. *International Journal of Biodiversity Science, Ecosystem Services and Management* 10(2): 101-111.
10. Nath CD, Pelissier R, Ramesh BR, Garcia C. 2014. Promoting native trees in shade coffee plantations of southern India: comparison of growth rates with the exotic *Grevillea robusta*. *Agroforestry Systems* 83: 107-119.
11. Gemechu HW, Lemessa D, Jiru DB. 2021. A comparative analysis of indigenous and exotic tree species management practices in agricultural landscapes of Southwest Ethiopia. *Trees, Forest and People* 4: https://doi.org/10.1016/j.tfp.2020.100059.
12. Derero A, Coe R, Muthuri C, Hadgu KM, Sinclair F. 2020. Farmer-led approaches to increasing tree diversity in fields and farmed landscapes in Ethiopia. *Agroforestry Systems.* doi: 10.1007/s10457-020-00520-7.
13. Dessie AB. 2019. Eucalyptus: the popular exotic tree crop in Ethiopia. *Acta Sci. Agric*. 3: 50-56.
14. Endale Y, Derero A, Argaw M, Muthuri C. 2017. Farmland tree species diversity and spatial distribution pattern in semi-arid East Shewa, Ethiopia. *For. Trees Livelihoods* 26: 199-214.
15. Neilson J. 2008. Environmental governance in the coffee forests of Kodagu, South India. *Transform Cult eJournal* 3(1): 185-195.
16. Abraham R, Purushothaman S, Devy S. 2013. Conservation and coffee production: creating synergies in Kodagu, Karnataka. *In*: (Eds) Purushothamn S, Abraham S. Livelihood strategies in southern India: conservation and poverty reduction in forest fringes. New Delhi (India): Springer India. pp 89-108.
17. Cerdán CR, Rebolledo MCG, Soto G, Rapidel B, Sinclair, Sinclair FL. 2012. Local knowledge of impacts of tree cover on ecosystem services in smallholder coffee production systems. *Agric Syst*. 110: 119-130.
18. Garcia CA, Bhagwat SA, Ghazoul J, Nath CD, Nanaya KM, Kushalappa CG, Raghuramulu Y, Nasi R, Vaast P. 2010. Biodiversity conservation in agricultural landscapes: challenges and opportunities of coffee agroforests in the Western Ghats, India. *Conservative Biology* 24: 479-488.
19. Shylesha AN, Veeresh GK. 1995. Incidence of coffee white stemborer *Xylotrechus quadripes* in major coffee growing tracts of Karnataka. *Journal of Hill Research* 8: 239-241.
20. Moguel P, Toledo V. 1999. Biodiversity conservation in traditional coffee systems of Mexico. *Conservative Biology* 13: 11-21.
21. Thapa S, Lantinga E. 2016. Infestation by Coffee White Stem Borer, *Xylotrechus quadripes*, in relation to soil and plant nutrient content and associated quality aspects. *Southwestern Entomologist* 41: 331-336.
22. Padma TV. 2018. Rainforest coffee better for taste and biodiversity, but needs policy support for farmers' income. Mongabay Series: Conserving Agro-biodiversity. Published on 10 Sept. 2018.
23. Gana Shruthy MK. 2019. Economies and Ecologies of Indigenous vs Exotic shade trees: Experiences from Coffee Based Agro-Forestry Systems in Kodagu. *Environment and Ecology* 37(3): 687-694.
24. Ambinakudige S, Sathish BN. 2009. Comparing tree diversity and composition in coffee farms and sacred forests in the Western Ghats of India. *Biodiversity Conservation* 18: 987-1000.
25. Kumar RA, Gopinandhan TN, Reddy PK, Uma MS, Patil S, Reddy GVM, Seetharama HG. 2019. Assessment of crop loss in Arabica coffee due to white stem borer, *Xylotrechus quadripes* Chevrolat (Coleoptera: Cerambycidae) infestation. *Journal of Plantation Crops* 47(3): 140-144.