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Identification of efficient attractant for the management of shot hole borer, *Xylosandrus compactus* infesting Coffee

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ABSTRACT: The shot hole borer (SHB), *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae: Scolytinae), is an emerging pest of Robusta coffee in India. Traps with attractants are commonly used to capture the ambrosia beetles for purposes of monitoring, studying population dynamics, predicting outbreaks, and mass trapping to reduce damage. The relative attractiveness of several common attractants and the influence of their concentration were evaluated in the field against *X. compactus* using Broca traps in this study. The tested attractants exhibited clear differences in attractiveness and the preliminary field studies at coffee plantations revealed that absolute ethanol attracted more shot hole borer adults than coffee twig extracts, distillery ethanol, and ethanol methanol combinations. The number of beetles trapped varied in different places during multi-location field trials, but in general, 50% of absolute ethanol-baited traps captured the highest number of beetles in all the locations. This study demonstrates 50% absolute ethanol can be used as an effective attractant for coffee shot hole borer and enables a cost-effective option for the control of *X. compactus* in coffee.

Keywords: Coffee, ambrosia beetle, *Xylosandrus compactus*, ethanol, mass trapping

INTRODUCTION

The Ambrosia beetle, *Xylosandrus compactus* (Coleoptera: Curculionidae) is a polyphagous pest that affects over 200 species, including coffee, forestry, and ornamental plants (Venkataramaiah and Sekhar,1964; Matsumoto, 2002,;Wu *et al.,* 2007; Chong *et al*., 2009; Gao *et al.,* 2017). It is native to Asia and is mostly found in subtropical and tropical locations (Hayato, 2007). In many countries, this beetle is predominantly reported as a Robusta coffee pest (Chacko, 1978; Hara and Beardsley, 1979; Vasquez *et al.,* 1996; Egonyu *et al.,* 2009). Until recently, it was considered as one of the minor pests and natural pruners in India. However, the incidence of this pest has grown significantly in recent years, particularly in Robusta coffee, and it has caused substantial damage, particularly in young plants (Roobakkumar, 2019). Though the exact reasons for the pest flare-ups in field situations are not clear, it is assumed that changes in climatic conditions and innovative grower practices such as drip irrigation coupled with fertigation, which contributes to luxurious vegetative growth with more succulent secondary and tertiary branches, are favoring pest build-up. The insect prefers green and succulent coffee shoots, but it will also infest the main stem if the plant is relatively young. The adult female beetles bore the coffee branches and makes a tunnel inside the branch for inoculating the symbiotic fungus *Ambrosiella xylebori.* Once the fungus developed inside the tunnel, adult beetle started to lay eggs and the emerged larvae grow inside by feeding on the fungus. Adult beetles and larvae do not feed on the tissues of the coffee tree; however, they survive by feeding the fungus inoculated by female adult beetle (Roobakkumar, 2019). This cryptic nature of the lifestyle inside the coffee plants makes it exceedingly difficult to manage this pest using conventional control methods. The available management methods for the pest are of limited success as the beetles are within the branches and do not feed directly on the vascular tissues. Pruning followed by the burning of infested twigs and application of fungicide, Propiconazole is the management measure adopted by coffee growers in India. When infestation levels become high, sanitation is a major concern to growers, as the removal of the copious amount of bearing branches from coffee plants significantly reduces the yield for the current and coming years (Greco and Wright, 2015). Though the recommended measures are effective, it is not economically feasible for most of the small coffee growers as it involves a large workforce. Further, the indiscriminate use of pesticides could contribute to undesirable problems in coffee plantations. At this juncture, switching to large-scale non-chemical management strategies is necessary to compete on the international market for a reasonable price for Indian coffee. The enormous crop loss caused by this pest and its life cycle warranted the development of easy, dependable, and environmentally sustainable management strategies. Traps baited with a chemical attractant are gaining importance nowadays for monitoring, analyzing the population dynamics, forecasting outbreaks, and mass

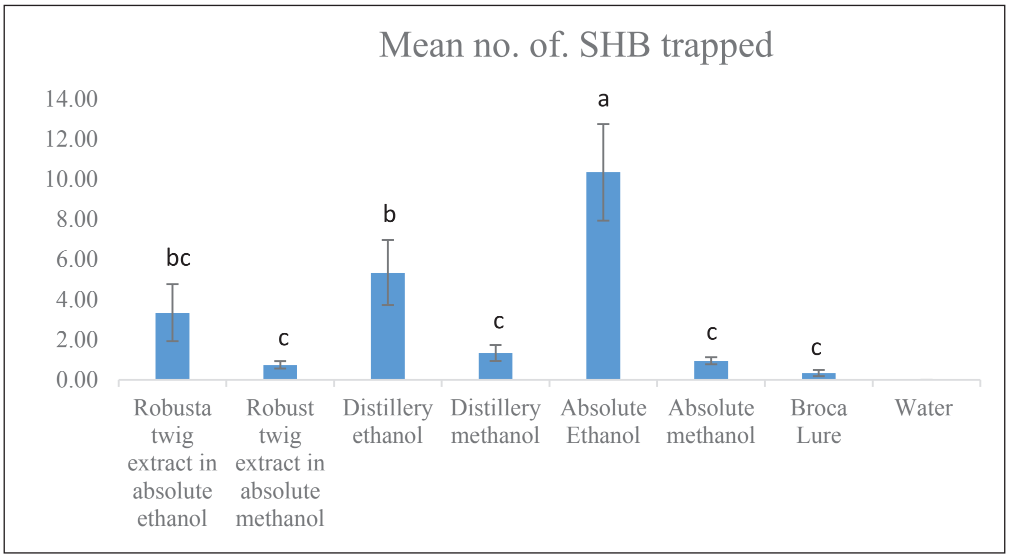

Fig. 1. Mean number of *X. compactus* captured per week in traps baited with different lures on robusta coffee plants (Means followed by the same letter do not differ significantly at *P* = 0.05 according to DMRT)

trapping. So far, the mass trapping strategy is not studied well for coffee shot hole borer in India. As mass trapping is one of the best IPM strategies if a strong attractant is available, the current study was initiated to find out an effective attractant for the management of coffee shot hole borer.

MATERIALS AND METHODS

Study Location

All the experiments except multilocation field trials were conducted in 40-year-old Robusta plants (Variety, Old Robusta) at the research farm of Central Coffee Research Institute (CCRI) located at 850 MSL (13°22'N75°28'E) in the district of Chikkamagaluru, Karnataka, India. This study site had enough shot hole borer infestation (around 80% of the trees had one or more infested twigs at the time of the survey). For multi-location field trials apart from CCRI, three private estates were selected viz., Nithin estate (Palya, Sakaleshpura), Hadhige estate (Mudigere), and Narendra estate (Munnurpal, Kalasa) from three different coffee growing zones of Karnataka, India.

The Trap

The trap used for all our experiments is the BROCA trap which is originally used for the management of Coffee Berry Borer. The trap consists of two units made up of polypropylene which can be threaded together, a small vial of 14 ml capacity with 10 ml lure is kept inside the trap and the whole trap is hung on the branches of the coffee plants approximately at the height of 1.5 m from the ground. Water is filled in the bottom half of the trap, which acts as the trap since the beetles that fall in the water are unable to fly again. The traps were recharged at weekly intervals by changing the water and checking for the level of the lure in the vials.

The attractants

Three field trials were conducted to evaluate the attractants to trap *X. compacts* in coffee plantations in south India. Trial 1 was designed to evaluate seven different attractants *viz.,* twig extracts of Robusta obtained using ethanol and methanol which is normally used for the attraction of insects. The other treatments like absolute ethanol (99.9% purity) and methanol (99.9% purity) of analytical grade were purchased from SD fine chemicals; distillery ethanol (95% purity) and methanol (95% purity) were purchased from the local distillery units. Solvent extracts were prepared following the methodology proposed by Karunaratne *et al*., 2008 by shaking the dried ground coffee twigs (500 g) of cultivar old Robusta with the distilled solvent, respectively ethanol and methanol (1.5 L) at 27° C for 24 hours followed by filtering and concentrating below 40° C on a rotary evaporator to obtain the extract, which was dried in a vacuum oven for 24 h before use.

Trial 2 was designed to compare the attractiveness of the most attractive lure from trial 1. Hence different concentrations of distillery ethanol and absolute ethanol were evaluated in the second trial. In the third trial, selected attractants were evaluated at multilocation to confirm the results.

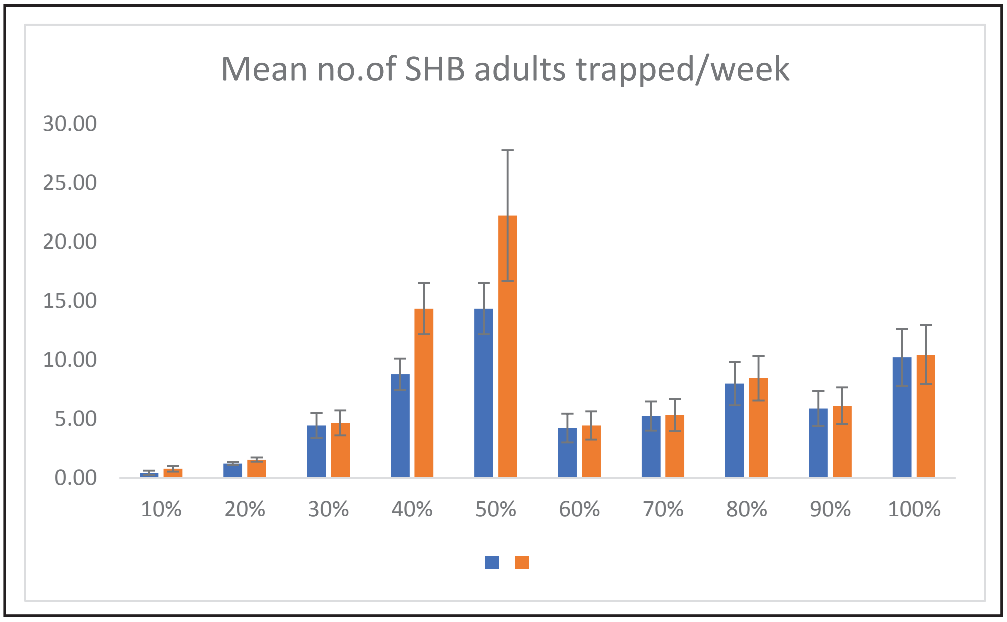

Fig. 2. Mean number of *X. compactus* captured per week in traps baited with different concentrations of Distillery ethanol (DE) and Absolute ethanol (AE) on robusta coffee plants (Means followed by the same letter do not differ significantly at *P* = 0.05 according to DMRT).

Experimental Design and Statistics

Each treatment was replicated 5 times. Broca Traps were deployed for all the studies. Traps were placed in a grid at 15 m intervals, 1.5m height above the ground on coffee plants and used a completely randomized design for the placement of treatments in the field. Experiments were conducted from September 2019 to February of 2020 and November 2020 to January 2021, trapped beetles were collected at weekly intervals. Every week, all the replications were rotated clockwise to avoid the experimental site error. 10 ml of each of the tested lures are placed in a small plastic vial inside the Broca traps which ran for the entire study period of 2 months. Insects were collected weekly by pouring the fluid through a fine (200 µ mesh) sieve. The insects retained on the sieve were transferred to the Entomology Laboratory (CCRI) for identification and counting. Differences between treatments on the attraction of shot hole borer adults were studied using analysis of variance (ANOVA) and the means were separated by Duncan's multiple range test (DMRT) (SPSS 10.0 1999).

RESULTS

Trial 1

The preliminary trapping studies conducted from September to November 2019 revealed that significant differences were observed in the mean number of adults captured among the tested attractants. Traps baited with absolute ethanol significantly attracted a greater number of adults compared to other attractants with 10.35 beetles/trap/week (Fig.1). Distillery ethanol-baited traps attracted the next highest number of adults, and it is on par with the Robusta twig extract in ethanol. No significant difference in the attraction was observed in the other tested attractants with the water-baited control.

Trial 2

Based on the preliminary observations, follow-up trials were conducted on the efficacy of different concentrations of distillery ethanol and absolute ethanol at CCRI. A comparison of the efficacy of ethanol (distillery and absolute) in different concentrations in trials conducted between December 2019 and February 2020 showed significant differences in the capture level between the distillery and absolute ethanol and different proportions. The comparative experiment indicated that absolute ethanol attracted a greater number of shot hole borer adults than distillery ethanol in all the concentrations. Whereas among the absolute ethanol, 50% concentration attracted a significant number of shot hole borer adults compared to all other proportions. Among the distillery ethanol, more attraction was recorded for 50% ethanol and the results are on par with 100% distillery ethanol (Fig.2). The trap catches increased with a concentration in both distillery ethanol and absolute ethanol up to 50%.

Table.1. Multi-location field evaluation of different attractants against *X. compactus*

Treatments	Mean no. of SHB adults attracted/week at different locations				Mean catch*
	CCRI	Mudigere	Sakaleshpura	Kalasa	
40 % DE	13.50 ± 1.94	4.75 ± 0.85	6.75 ± 0.48	14.00 ± 1.47	9.75 ± 2.35b
50 % DE	17.50 ± 2.96	6.00 ± 0.91	8.50 ± 0.96	17.00 ± 1.68	12.25 ± 2.93b
100 % DE	14.00 ± 2.83	5.25 ± 0.63	7.50 ± 0.29	12.75 ± 2.56	9.88 ± 2.09b
40 % AE	16.50 ± 1.55	7.75 ± 0.25	8.50 ± 0.65	16.75 ± 1.55	12.38 ± 2.46b
50 % AE	27.00 ± 2.08	26.75 ± 2.06	28.50 ± 1.26	27.75 ± 1.55	27.50 ± 0.40a
100 % AE	17.25 ± 0.48	12.50 ± 0.87	15.75 ± 2.17	14.75 ± 2.43	15.06 ± 1.00b
Water (Control)	0.25 ± 0.25	0.25 ± 0.25	0.00 ± 0.00	0.25 ± 0.25	0.19 ± 0.06c

Trial 3.

Based on the results of trials 1 and 2, multi-location field trials were conducted from September 2020 to January 2021 using the effective proportions of distillery ethanol and absolute ethanol to find out an efficient and economic attractant for *X. compactus*. The multi-location field trials showed that 50 percent absolute ethanol attracted the maximum number of shot hole borer beetles to the traps (Fig. 4b) in all the tested locations. The overall result of the experiment indicated 50% absolute ethanol attracted a significant number of beetles which was approximately twofold more compared to all other evaluated concentrations. This trend in trap catches has been observed throughout the study period in all the tested locations.

DISCUSSION

This work was aimed to identify the best attractant and thus to develop a trapping technique for managing shot hole borer infestation in coffee plantations in India. Field evaluation was carried out from November to January when the shot hole borer incidence was more in the coffee estates. Ethanol extracts from wood and bark act as the primary attractant of several ambrosia beetles and is responsible for increasing their attack rate (Moeck 1970, Bhagwandin 1992, Shore and Lindgren 1996). Concentrations and release rates are the factors that have might have affected the shot hole borer attraction, therefore, treatments like coffee twig extracts in ethanol and methanol along with commercial ethanol and methanol were tested in different concentrations. The finding of our study revealed that higher capture rates were obtained for ethanol in the preliminary studies which confirms the previous observations by Moeck 1970, Oliver and Mannion 2001, Hoagland and Schultz 2006, Miller and Rabaglia 2009, Burbano *et.al.,* 2012 and Avinash *et.al.,* 2021. Further field trials on the different concentrations of absolute and distillery ethanol clearly indicate the significant attraction for absolute ethanol compared to distillery ethanol. Our results demonstrated, *X. compactus* was significantly more attracted to 50% Absolute ethanol than either distillery ethanol or methanol. The difference in attraction between the distillery and absolute ethanol could be because of the difference in the degree of purity of ethanol. Our finding is in contrast with Avinash *et.al.,* 2021 who reported *X. compactus* was attracted more towards 95% absolute ethanol rather than 50% absolute ethanol.

Effective attractants can be used to set up a trapping program to examine this beetle's seasonality and flying behaviour. Traps can be used as an early warning system to identify the presence of *X. compactus*, as well as scheduling time for pesticide application. If a powerful attractant is available, traps may be effective as a mass trapping technique. In coffee plantations, an effective trapping system might be part of an integrated management approach for *X. compactus*. Hence, 50% absolute ethanol might facilitate implementing the strategy for management purposes.

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