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Efficacy of Bapronil 50 SC (Fipronil 50g/lt) for Management of African White Coffee Stem Borer, *Monochamus leuconatus,* Pascoe

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Abstract— The African coffee stem borer, *Monochamus leuconotus*, Pascoe (Coleoptera: Cerambycidae) is an important pest of Arabica coffee in Tanzania. Its management used to be based on Organochloride chemicals, but since the chemicals were banned has been no effective alternative chemical(s). This study investigated Fipronil 50g/lt and Chlorpyrifos 480 EC as standard for management of the pest and assessing for any residual accumulation in coffee beans and cup quality. The experiment was established in four sites from 2015 to 2018. A Random Complete Block Design (RCBD) was used with 6 treatments replicated 3 times. The treatments included four dosages of Fipronil 50g/lt (15, 20, 25 and 30 mls/20lt of water), Chlorpyrifos 700 ml/20lt of water (standard) and control (untreated). Chemicals which were banded on coffee stem (90 cm) from the ground two weeks before rain season. The number of holes made by the pest were counted before and after the application of treatments (old and new holes) at three months interval and coffee cherries were collected for residue levels and cup quality evaluation. Collected data were analyzed using GenStat software. Results showed both Fipronil 50g/lt and Chlorpyrifos 480 EC at all concentrations significantly ($p \leq 0.05$) affected the number of holes, with 15 mls/20lt of water and the standard recording the lowest number. Pesticide residues assessment showed minimum risks and cup quality had no tainting effect. Fipronil 50g/lt at a rate of 20 mls/20 lt of water, which did not show significant difference from the highest dosage, is hereby recommended for farmers' use.

Key words: Arabica coffee, Chlorpyrifos, Fipronil, *Monochamus leuconatus*, Tanzania

1 Introduction

INTRODUCTION

The African white coffee stem borer (WCSB), *Monochamus leuconotus*, Pascoe (Coleoptera: Cerambycidae) is a major threat to Arabica coffee production in Africa. This includes; Kenya, Uganda, Republic of Congo, Cameroon, Angola, Malawi, Zimbabwe, Mozambique, South Africa and Tanzania. Major damage is through ring barking and stem boring by the larvae that interrupt the translocation of metabolites [1], [2]. This cause yellowing of foliage of coffee tree, shoot die-back and varying degrees of defoliation [3]. Ring barking is particularly destructive for younger trees with small trunk diameter but rarely circles the trunk of larger trees [4]. Young trees may therefore be killed quite rapidly but older trees can survive, although remain in an unproductive state [5]. Incidences of white coffee stem borer on small-scale farms in northern Malawi was reported to be up to 80% [6]. In Tanzania one stem borer in one 15-year old coffee tree was estimated to cause crop losses of 8% [7]. Cumulative yield losses of up to 25% was reported in South Africa in 1997 [8] which makes the cultivation of coffee uneconomical [9]. The white stem borer will ultimately destroy the entire plantation if the field is not attended [8] and this has caused some farmers in Tanzania to abandon their coffee farms or stamping and replacing by young seedlings every year [10].

Depending on temperature WCSB lays between 10 and 40 eggs, but in East Africa it is normally between 20 and 25 eggs [11]. The eggs of the pest are laid beneath the bark of the coffee tree and requires about 3 weeks to hatch [8]. Young larvae feed just beneath the bark. The larva emerged from eggs laid near ground level, burrow down into the roots and those laid higher upper from ground level girdles upwards the trunk. There are 7 larval instars which lasts for an average length of development of 16 to 20 months [7], [12]. The larva which is a destructive stage excavates large chambers within the trunk and pupates between two and four months and lasts 4 to 5 weeks and the adult remains within the tree for a further 2 weeks. The average length of the insect's development from egg to adult is 1½ to 2 years depending on weather conditions [2], [7].

In the past (1950 – 1970) the pest was well managed by use of Organochlorine pesticides especially Dieldrin and Aldrin as stem paints [1], [2]. The chemicals were banned in 1974 due to side effects like persistence in the environment, health concerns in humans and threat to non-target organisms, leaving no alternative(s) for effective management of the pest [13]. As a result, growers have seen a resurgence of the pest which became difficult to manage. Current control measures involve keeping coffee trees healthy through fertilizer application, smoothing the bark of the lower stems (50 cm from the ground) using a rough cloth or maize cob to remove crevices for oviposition, killing larvae inside the stems by driving a wire, inserting a cotton wool dipped in kerosene/chemical to

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kill the larva, wrapping lower base of coffee stems with banana leaves to cover the area of egg laying and uprooting and burning the seriously infested trees before the onset of rains [1], [14]. All these practices are very cumbersome and tedious to apply especially on medium and large-scale farms. Field trials conducted in Malawi and Zimbabwe with Fipronil 50 g/lt. as stem paints, showed the chemical to be promising for preventing the invasion of the pest [5], [15]. Also, in Zimbabwe, Malawi and Kenya Chlorpyrifos were reported as effective as stem paints for the pest [5], [9], [12]. Efficacy of any of these chemicals has not been verified experimentally in Tanzania for management of the pest. Hence, the objective of this study was to evaluate the efficacy of these chemicals for management of WCSB in the farmers' fields, checking for any residual accumulation in coffee beans and any effect on cup quality.

2 METHODOLOGY

2.1 Description of the study location

Four field experiments were conducted in four Arabica coffee agro-ecological sites in the period between April 2015 and March 2018; Two trials were established in coffee estates (Burka and Tingatinga, in Arusha region) while the other two trials were established in smallholder farmers' fields in Southern highlands (Luwaita village in Mbinga district, Ruvuma region and Mwayaya village in Buhigwe district, Kigoma region). The trials were superimposed on the already established coffee trees for an average of 35 years old. The four agro-ecological sites selected are renowned both as high coffee production areas and as WCSB hotspots.

2.2 Experimental design

A Randomized Completely Block Design (RCBD) with three replications was used to compare six (6) different dosages namely Fipronil (four dosages 15, 20, 25 and 30 mls/20 lt of water), Chlorpyrifos 700 mls/20 lt of water (used as a standard) and control (untreated). The Fipronil dosage were determined based on the observation by [15] in Zimbabwe who observed a rate of 25 mls/20 lt of water gives a promising result, hence we added 5 mls more and 5 to 10 mls less from 25 mls/20 lt. Two weeks before the short and long rains the dosages/treatments were applied by banding/spraying on coffee stems at a height of 90 cm from the ground. The treatments were applied in plots with nine coffee trees (3x3) and were separated by one line of coffee to act as a guard row to prevent possible drift of insecticides from adjacent plots.

2.3 Data collection and analysis

Data recorded included number of holes made by the pest before and after the application of treatments (new infested holes) and coffee yield per tree before and at the end of the trial. Some new holes made by the larva of the pest were recorded after every three months interval to allow any new re-infestation by the pest. Also, coffee cherries were collected from the trees banded/sprayed with the chemical and sent to Tropical Pesticides Research Institute (TPRI) in Arusha region to assess for any residual accumulation and translocation to coffee beans and whether such residues could have an effect on cup quality. Evaluation of cup quality was done by zonal cuppers where the trial was established using cherries that were collected from trees banded/sprayed with the chemical and controls (untreated). Data recorded were analyzed by use of GenStat (12th Edition) statistical software. Means separation was done according to Fisher's protected LSD test at 0.05 level of significance.

RESULTS

Efficacy of the product and yield performance

Results indicated that the treatments had significant effect ($P \leq 0.05$) on number of holes caused by larva of WCSB across locations. Fipronil at a rate of 30 mls/20 lt of water performed best at Burka, whereas in overall it seems Chloropyrifos 700mls/20 lt water was the best in all locations, followed by Fipronil at a rate of 25 and 20 mls (Table 1). On the other hand, Fipronil at a rate of 15 mls/20 lt of water and the control (untreated) significantly ($P \leq 0.05$) differed in the number of holes as compared to other three concentrations (30, 25 and 20 mls/20 lt of water). No significant ($P \leq 0.05$) differences were observed between holes made by the pest at 700 mls of Chlorpyrifos and all dosages of Fipronil from 20 mls/20 lt of water and above in different locations.

Table 1: Mean number of holes made by larva of WCSB in coffee stems in the field after application of different dosages for 3 seasons in different ecological zones/location

Treatments		Application rate	Location of trials				
Common name	Trade name	Rate/20lt	Burka	Tingatinga	Luwaita	Mwayaya	Combined
Chlorpyrifos	Dursban	700 mls	7.7**a**	5.3**a**	5.7**a**	8.7**a**	6.8**a**
Bapronil50 SC	Fipronil	30 mls	9.0**a**	7.0**ab**	6.7**ab**	**9.0a**	**7.9a**
Bapronil50 SC	Fipronil	25 mls	10.0**a**	8.0**ab**	7.3**ab**	**10.3a**	**8.9a**
Bapronil50 SC	Fipronil	20 mls	10.0**a**	8.0**ab**	7.7**ab**	11.0**a**	9.2**a**
Bapronil50 SC	Fipronil	15 mls	16.3**b**	14.0**b**	12.7 b	17.0**b**	15.0**b**
Control		-	30.7**c**	24.7**c**	28.7**c**	30.3**c**	28.6**c**
Mean			13.5	11.2	11.5	14.4	12.7
P-value			0.001	0.001	0.001	0.001	0.001

Means followed by the same letter(s) are not significantly different ($P \leq 0.05$), according to Fishers Protected LSD

At the beginning of the trials, pre-treatment holes made by larva of the pest had been counted. High infestation of the pest (number of holes) was observed at Mwayaya followed by Burka coffee estate, while Luwaita and Tingatinga coffee estate had recorded the lowest. After treatment application a consequent decrease in the number of holes was observed (Table 2).

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Table 2: Average number of holes made by larva of WCSB before and each year after the application of Fipronil at a dosage of 20 lt per 20 lt of water in four locations

Years	Locations			
	Burka (Arusha)	Tingatinga (Arusha)	Luwaita (Ruvuma)	Mwayaya (Kigoma)
Pre-treatment	**7.0**	**4.0**	**6.0**	**8.0**
Year 1 (2016)	6.0	4.0	4.0	7.0
Year 2 (2017)	3.0	3.0	3.0	4.0
Year 3 (2018)	2.0	2.0	1.0	1.0
Grand total	**11.0**	**9.0**	**8.0**	**12.0**

With treatment, there was an increase of coffee production from 0.5 Kg to 2.0 Kg parchment/tree (300% increase) in the farmers' fields in Luwaita, Mbinga and 0.75 Kg parchment /tree (178.5% increase) in Mwayaya, Kigoma and in estates for both Tingatinga coffee estate (Karatu) and Burka (Arusha) from 1 Kg to 2.5 kg/parchment (150% increase) (Table 3).

Table 3: Estimated average yield parchment per tree in four locations per three years

	Burka, Arusha (coffee estate)		Tingatinga, Arusha (coffee estate)		Mwayaya, Kigoma (Small farmer)		Luwaita, Ruvuma (Small farmer)	
Years	2016	2018	2016	2018	2016	2018	2016	2018
Kg/tree	1	2.5	1	2.5	0.75	2.25	0.5	2.0
% increase		150		150		178.5		300

Cup quality and residue levels evaluation for coffee beans

The results of cup quality done by different cuppers in the zones where the trials were established indicated clean coffee, sweet and medium clean and light medium acidity (Table 4) and there was no tainting flovour.

Table 4: Results of cup quality evaluation

S/No.	Location	Description	Remarks
1	Tingatinga (Manyara)	Clean	Acceptable by consumers
2	Mwayaya (Kigoma)	Sweet and medium clean	
3	Luwaita (Ruvuma)	Light medium acidity	
4	Burka (Arusha)	Clean	

Also, the results for levels of pesticide residues remaining in the coffee beans from samples collected from two locations in Tingatinga Coffee Estate (Arusha region) and Burka Coffee Estate (Arusha region) as representative samples for other locations were assessed by TPRI in Arusha and indicated no pesticide residues found in the coffee beans (Table 5).

Table 5: Results of pesticide residues of coffee beans in different locations

Location	Residue levels description
Tingatinga (Arusha region)	No pesticide residue found
Burka (Arusha region)	No pesticide residue found

DISCUSSIONS

The new chemical Bapronil 50 SC (Fipronil 50g/lt) has shown to be potential in the management of WCSB, whereby the efficacy to control the pest increases with the increase in concentration. This related with a report by Kutywayo (2015) in Zimbabwe who reported a rate of 25 ml of Fipronil/20 lt of water when applied to the first 50 cm of the coffee stem, to be effective in controlling the pest. Also, field trials conducted in Malawi with Fipronil applied as stem paints showed the chemical to be effective in preventing the invention of larva of the pest [2]. Similarly, in all established trials there was a decrease in number of holes made by the larva of the pest from year one to year three, which implies less infestation rate of the pest as the time increase. This observation may be due to the repellant effect caused by the chemical banded on the trunk which its toxic smell repels the female from laying their eggs and later damage the coffee tree. In addition, the production per tree at the end of the trial slightly increased as compared to production before the application of the treatments. It is suspected that the chemical may have the killing effect of the eggs laid on crevices by the pest, which reduces the pest population level and hence an increase of production per tree. Across the trials in different location an increase of production was observed which implies the pesticide has an effect against the pest infestation population levels.

During the evaluation of the trials farmers in all trial sites requested the product to be available in the market for farmers use. For example, a farmer from Luwaita in Mbinga explained that before the establishment of the trial in his farm, more than 50% of his farm was infested by the pest and the production was low (below an average of 200g/tree). But after establishment of the trial by the chemical the pest has dramatically decreased its infestation and the production has increased.

Chlorpyrifos, used in this work as standard, has proved to be as effective for management of the pest in Tanzania as in the other countries (Malawi, Zimbabwe and Kenya). However, Chlorpyrifos at price of TZS 23,000/- per litre, and at a rate of 700 mls/20 lt of water formulation is much more expensive as compared to Bapronil 50 SC (Fipronil 50g/lt) at price of 150,000/= per litre at a rate of 20 mls/ 20 lt of water when equally applied in a unit area (Table 6). Hence Bapronil 50 SC (Fipronil 50g/lt) at a rate of 20mls/20 lt of water is therefore cheaper and more appropriate for farmers use. The results for residue levels evaluated from coffee beans collected from the trees sprayed with Fipronil showed minimum risks while the cupping quality taste also showed no tainting effect which is good for consumers. With treatment, there was an increase of coffee production from 0.5 Kg to 2.0 Kg parchment/tree (300% increase) in the farmers' fields in Luwaita, Mbinga and 0.75 Kg parchment /tree (178.5% increase) in Mwayaya, Kigoma and in estates for both Tingatinga coffee estate (Karatu) and Burka (Arusha) from 1 Kg to 2.5 kg/parchment (150% increase) (Table 3).

Table 6. Rate of application per hectare (ha) and the estimated prices in Tanzanian shillings and US dollars.

Name of chemical	Rate of Application		Price (Tshs)		Price ($)
	Per 20 lt of H_2O	Per Ha	Price/lt	Price/Ha	Price/Ha
Fipronil	20 mls	2 lt	150,000/=	300,000/=	130.43
Chlorpyrifos	700 mls	70 lt	23,000/=	1,610,000/=	700.00

<u>**Note:**</u> 1. One US dollar is estimated at a rate of 2,300/= Tshs
2. Estimated 2,000 trees/ha (20 tree/20 lt of pesticide mixture)

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CONCLUSION AND RECOMMENDATIONS

All the tested dosages of Bapronil 50 SC Fipronil 50g/lt) have shown a potential for management of WCSB although the efficacy varied depending on the concentration used. For economic reasons we recommend Bapronil 50 SC (Fipronil 50g/lt) at a rate of 20 mls in 20 lt of water to be used for banding/spraying on coffee stems. For good management of the pest it is recommended to apply the chemical at the beginning of short rains and long rain (estimated two weeks before) which will prevent/repel the adult female pest from laying the eggs on the trunk after mating.

Since Bapronil 50 SC (Fipronil 50g/lt) has shown to be effective and cheaper in the management of the pest and has minimum risk, it is important for the product to be used by coffee farmers to control the pest in the field. TaCRI and owner of the product (Bajunta International (T) Ltd) after consideration for approval we will prepare awareness creation program for promotion of the product to all coffee farmers were the pest is a problem in the country.

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