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RESEARCH ARTICLE

On Farm Assessment of Cassava Leaf Extract Biopesticide in Controlling Banana Pseudostem Weevil and Popularization of the Technology

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ABSTRACT

Pseudostem weevil (*Odoiporus longicollis*) attacks banana crop from 5th month of planting by adult female weevil inserting eggs into pseudostem cavities and emerging out grubs feed on the internal tissues. This weakens the pseudostem leading to the collapse of the plant. The yield loss due to this pest is estimated as 10-30 per cent and in some cases, it may be up to 90 per cent. Indiscriminate usage of chemical pesticides causes resistance in weevils and also results in pesticide residues. It is in this context that a field experiment was conducted to study the effectiveness of bio pesticide from Cassava leaf extract in controlling banana pseudostem weevil. Banana (var. Nendran) fields of 6 ha area scattered in three villages of Ernakulam district, Kerala was selected to conduct the field study. The effect of cassava leaf extract biopesticide was compared with that of Chlorophyriphos. Data on pest incidence, crop damage, and yield were recorded. No crop damage was reported among the plants treated with the bio pesticide. Crop damage to the extent of 19.92 per cent was recorded in plants treated with Chlorophyriphos and 45.16 per cent of plants got damaged in plots where no treatment was done. The average increase in bunch weight by 52 per cent was recorded in plants treated with the biopesticide against 24 per cent increase in bunch weight in plants treated with Chlorophyriphos. Various extension methods were employed to popularize the technology and farmers' responses were assessed and reported.

Keywords: *Cassava biopesticide; Odoiporus longicollis; Pest management; Plantains*

INTRODUCTION

Banana is one of the oldest fruit crops which belongs to the genus Musa that are found in different parts of the world. India ranks 1st in terms of global production and major banana producing states in India are Kerala, Tamil Nadu, Maharashtra, Gujarat and Assam. Banana is cultivated in 0.53 lakh ha area in Kerala with an average yearly production of 4.3 lakh MT and productivity of 8.1 $MTha^{-1}$ (Agri. Stat. 2018-19, GOK). Ernakulam district of Kerala ranks 4th in terms of area and production and ranks 1st in productivity in the state.

Different insect pests have been reported from various parts of the world that are destructive to the banana crop. The banana pseudostem weevil, *Odoiporus longicollis* (Oliver) (Coleoptera: Curculionidae) is a major pest that affect the growth of banana and plantain in South-East Asia. (Padmanaban *et al*., 2001). The pseudostem weevil is a very serious pest that limits the production and reduces the productivity of bananas and plantains in most parts of India and other countries like Burma, Sri Lanka, Bangladesh, and Indonesia (Justin *et al*., 2008). In India, it is more prevalent in states like Bihar, West Bengal, and Assam and it was recorded for the first time in 1989 at Kerala. Varieties *viz.,* Nenthran and Red Kappa are highly susceptible to this pest (Visalakshi. *et al*., 1989). Banana pseudostem weevil preferred the variety *Musa AAB Cv.* Nendran followed by Kappa and Morris. Njalipoovan is the least preferred variety (Padmanaban *et al*., 2001). It is a monophagous pest and both larvae and adults cause severe damage to banana and plantains (Justin *et al*., 2008). Planting of infected rhizomes, poor management practices, and indiscriminate application of chemical pesticides were the factors causing the weevil infestation for more than five months old plantains, particularly in summer seasons (Tiwari *et al*., 2006).

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The weevils are predominantly nocturnal in habit and often confine themselves within the pseudostem and in the decomposing tissues of harvested pseudostems (Padmanaban *et al*., 2001). Female by its rostrum makes a slit into the leaf sheath and thrust the eggs within the air chambers. The larva is soft bodied, without legs (apodus), fleshy, wrinkled with brown hairs covered all over the body. The larva bores tunnel into the pseudostem which weakens the affected part and causes decomposition of the tissues. The grubs are more destructive than the larvae and adults. After hatching, the grubs feed on tissues of leaf sheath and then bore their way into the pseudo stem causing weakening and decomposition of the pseudostem resulting in a collapse during strong winds. The adult feeds on the inner part of the leaf sheath and decaying tissues. The pest-infected plantains show exudation of sap from the leaf sheaths, leaves become yellowish and start withering. The decaying of peduncles results in the immature ripening of fruits (Justin *et al*., 2008).

The yield loss is estimated at around 10-30 per cent and it depends on the stage of the crop at which it gets infested. In some cases, a crop loss varying from 10 per cent to almost 90 per cent results depending upon the stage and the efficiency of management practices (Padmanaban *et al*., 2001). The Economic Threshold Level for banana pseudostem weevil is put at 5 per cent pest infested plants. Infestation by weevils perpetrates hefty crop loss (Padmanaban *et al*., 2001).

Most chemical pesticides are recommended in controlling this pest. Research results suggest the application of quinalphos 0.05 per cent or chlorpyrifos 0.03 per cent or carbaryl 0.2 per cent to reduce crop damage (POP, KAU, 2011). Spraying carbaryl (0.2%) or Endosulfan (0.05%) periodically keeps the population of the pest under control. Field sanitation, use of healthy suckers, periodical pruning of suckers and removal and destruction of infested pseudostems can reduce the incidence of the pest (Justin *et al.,* 2008). Injecting 2 mL monocrotophos or dimethoate along with water at 1:5 ratio at 60 cm of the stem and 150 cm from ground level was significantly superior in controlling the pest (Justin *et al*., 2006.). Swabbing of insecticide over the pseudostem with monocrotophos at the rate of 2mL litre^{-1} during 6th and 7th month of planting can control the infestation to some extent. Stem injection of monocrotophos 150 mL diluted in 350 mL water at the rate of 2mL plant^{-1} using a stem injector at 30^{o} angles in two places, one at two feet height from the ground and the second at four feet, above the ground level is effective if the feeding damage is noticed after 7 months of planting. Chemical insecticides warrant long-term ill effects, including insecticidal resistance in the target pests (Gold and Messiaen, 2000), pest resurgence, pest outbreak, groundwater contamination, and drastic effects on beneficial insects (David and Vasantharaj, 2008) apart from the environmental imbalances due to tottering ecosystem.

To lessen the ill effects of chemical pesticides on man and the environment, a global mobilization is set off for finding out alternative green technologies to contain insect pests in the cropping system. As management of weevil pests using chemical methods harmful to the environment and cultural methods only partially successful, an alternative approach of plant defense mediated by endophytic fungi *Beauveria bassiana* isolate KH3 was exploited as a potential biocontrol agent for reducing insect population and stem damages in banana by the lure and kill method by (Alagesan *et al*., 2019). Swabbing of mud slurry with 3 per cent neem oil emulsion around the pseudostem or application on the pseudostem and leaf axil filling with Entomopathogens *Beauveria bassiana* or *Metarhizium anisopliae* at the rate of 1 x 10^{7} spores mL^{-1} can also be used in containing the pest infestation (Adhoc POP- KAU, 2009). Although all these chemicals are recommended, the farmers generally used Chlorophyriphos 20 % EC and Carbaryl for controlling the menace.

Stem injection of Neem Azal (4:4) recorded 93.81 per cent mortality of pseudo stem weevil after 96 hours of application (Sivasubramanian *et al*., 2009). The pest status of the banana weevil can vary depending on local agro-ecological conditions and Musa cultivars (Gold *et al*., 2001). Various methods are used by farmers to control the pest, but all the methods have not been evaluated for their efficacy or their potential integration with other practices (Karamura and Gold, 2000). Indiscriminate application of pesticides results in higher chemical residues in bananas. Often, erratic usage of chemicals also caused resistance in the pest against many pesticides. Other possibilities for control include biological control with botanical or synthetic pesticides (Gold *et al*., 2001). With organic farming gathering, momentum and the growing concerns on health in view of vegetables and food crops contaminated with pesticide residues resulted in a shift towards organic methods of crop production. Bio pesticide formulation from Cassava leaf extract is effective in controlling banana weevil and its application could reduce the crop loss from 40 percent to less than 1 per cent (Hali, 2016). Cyanogen is the main active principle in cassava biofumigant and this has been an approved chemical for pest management strategies. The underutilized plant parts such as leaf and tuber rind of cassava are used for the production of biopesticides against borer pests of fruits and tree crops, Excellent package of

control was developed both by prophylactic and curative means against the banana weevil (*Odoiporous longicollis* (Oliver) and *Cosmopolitus sordidus* (Germer) management and over many of the noxious pests of vegetable and fruit crops (Jithu *et al*., 2017). The Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram has isolated the cyanogen derivatives and standardized techniques for the generation of Cassava-Bio Fumigant (CBF) from this plant against the insect pests in many horticultural crops (Ajesh *et al*., 2018). As reported by FAO in 1989 continuous exposure to Cyanogens for more than two hours at 100 ppm only causes anoxia to humans. Management of banana weevil (*Odoiporous longicollis* (Oliver) was achieved using the two formulations as prophylactic and curative measures (Jithu Unni Krishnan *et al*., 2015)

Hence a field study was conducted to record the efficacy of biopesticide formulation made from cassava leaf extract and acceptance of the method among farmers. The feedback of farmers is also compiled.

MATERIAL AND METHODS

A total of 6 ha area belonging to 12 farmers serially numbered from 1 to 12, scattered in villages, Thirumarady, Chendamangalam and Mookkanoor of Ernakulam district, Kerala was selected for the study, and the farmers sufficiently trained on scientific banana cultivation. The soil type in all the plots was laterite, average rainfall during the study was 263.24 mm, and relative humidity 82.7 per cent. The soil nutrient status of plots (Kg ha^{-1}) is provided in Figure 1.

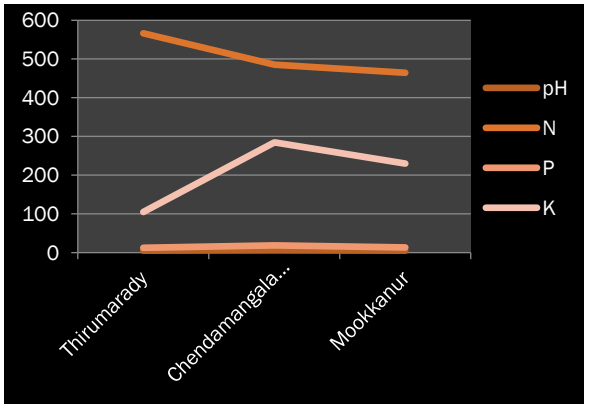

Figure 1. Soil nutrient status of selected plots

Sword suckers of banana variety Nendran, 3 to 4 months old were selected, roots removed and the rhizomes smeared with a slurry prepared with cow dung, ash, and water mixed in the ratio 1:1:5, dried in shade for 3 days, and stored for 15 days. Planting pits of size 0.5×0.5×0.5m at a spacing of 2×2 m made, powdered lime 1 kg applied and subsequently leaving a gap of 10 days, farmyard manure 10 kg and 500 gm Neem cake were applied and suckers planted during September. Flood irrigation was followed in 5 days intervals during the period January to April. Nitrogen as Urea in equal splits of 35 g each at 30, 60, 90, 120, 150, and 210 days of planting, Phosphorous as SSP in splits 325 g on 30th day and 250 g at 60th day of planting, and Potash as MOP in 5 equal splits at 30, 60, 90, 120 and 150 days after planting was the fertilizer schedule followed.

Three plots (plot number 1, 2, and 3) of a total 1 ha area together containing 2000 numbers of plants were kept as control where no treatment for pseudostem weevil administered. Chlorpyriphos treatment was administered in 3 plots (plot number 4, 5 and 6) having a total area of 2.5 ha area containing 5255 numbers of plants. The Chlorpyriphos treatment involved a spray of 0.25 per cent concentration of 20 EC Chlorophyriphos 3 times in the pseudostem at an interval of three weeks from 120 days of planting. The cassava leaf extract was administered in 6 plots (plot numbers 7, 8, 9, 10, 11, and 12) having a total area of 3.25 ha containing 6685 plants. The cassava leaf extract of 5 per cent concentration was sprayed at the pseudo stem below the crown portion on the 120th and 150th days of planting at the rate of 100 mL spray fluid per plant in the experimental plots. Data on parameters *viz*., pest incidence, crop damage, and yield were recorded. The pest incidence per infestation or intensity was the ratio of number of plants on which the pest was noticed to the total number of plants. Crop damage was the ratio of number of plants that fell due to pest attack to the total number of plants. One in ten of the harvested bunches was selected randomly to measure individual bunch weight in a platform electronic weighing balance of accuracy 10 gm. The total weight of bunches was also recorded. A pretested schedule was used to collect data on farmers' perception on this technology with reference to cost-effectiveness, method of application, pest incidence, crop damage, yield and net income.

Results and Discussion

A comparison of the effect of chemical and biopesticide treatments against banana pseudostem weevil is provided in Figure 2. More than half of the plantains recorded pest incidence and nearly half of plantains got damaged totally in untreated plots. The chemical treatment of Chlorophyriphos could reduce the infestation level to 31.27 per cent and only 19.92 per cent of plantains got damaged in this case. Very meager infestation of 0.12 per cent only was recorded in plots treated with biopesticides and none of the plantains got damaged. The yield per plantain was as high as 10.96 kg/ plant in biopesticide treated plots. Farmer's 86.66 per cent perceived that cassava extract biopesticide is effective as already reported by Jithu *et al*., 2017. Farmers 93.33 per cent felt that biopesticide can be easily applied as the procedure is very simple. All the respondents felt that biopesticide is the most cost-effective method available for controlling banana

pseudostem weevil menace. All the respondents also perceived that there was no damage in bio pesticide applied fields that indicating that this method is superior to existing methods. The improved yield was noticed by all respondents in biopesticide applied fields. All the respondents realized higher net income from the biopesticide applied fields. Therefore, it is confirmed that the biopesticide Nanma is more effective than any other existing methods in controlling banana pseudostem weevil.

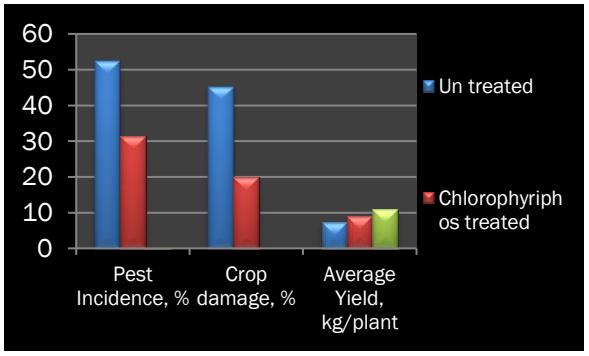

Figure 2. Comparison of chemical and biopesticide treatments against banana pseudostem weevil

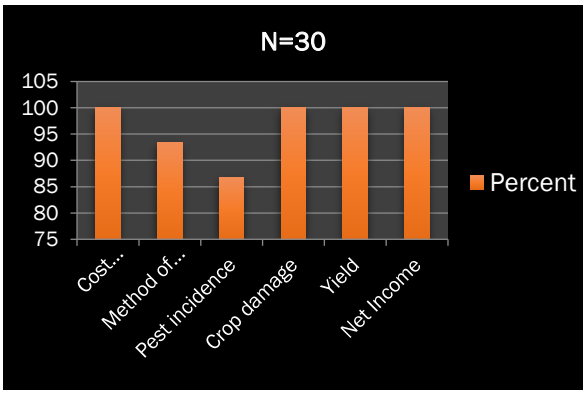

Figure 3. Banana farmer's perception of the cassava leaf extract biopesticide

Table 1. Milestones in popularizing cassava leaf extract biopesticide in Ernakulam district, Kerala

Year	Milestones
2013	• Conducted on farm testing of cassava leaf extract biopesticide in managing Banana pseudostem weevil in 7 fields in Ernakulam district, Kerala
2014	• Conducted frontline demonstration of cassava leaf extract against banana pseudostem weevil in 3.25 ha area in Ernakulam district, Kerala by participating 12 farmers.
2015	• Purchased technology of cassava leaf biopesticide from ICAR- Central tuber crops research institute, Thiruvananthapuram, Kerala. • Presented results in the first KVK symposium, Zone VIII held on 22nd January, 2016 at UAS, Dharwad
2016	• Commenced production and supply of Cassava leaf biopesticide under trade name Nanma. • 625 litres of biopesticides supplied to farmers
2017	• Field demonstration conducted • 527 litres of biopesticides supplied to farmers
2018	• 300 litres of biopesticides supplied to farmers • designed and developed a biopesticide homogenizer and mechanized the production process
2019	• 275 litres of biopesticides supplied to farmers
2020	• 161 litres of biopesticides supplied to farmers

Table 2. Extension methods adopted to popularize Cassava leaf extract biopesticide in Ernakulam district, Kerala

Year	Activity	Beneficiary	Number of farmers covered	Number of extension workers covered
2015	Monthly technology advisory meeting of Agricultural technology management agency (ATMA), Ernakulam district	Lead farmers and Extension workers	5	50
	Field day	Farmers and Extension workers	75	5
	Media reports	Farmers and Extension workers	750	100
2016	Capacity building programme	Farmers	35	--
	Exhibition	Farmers	600	--
	Television documentary	Farmers	1500	50
	KVK Newsletter	Lead farmers and Extension workers	15	275
	Capacity building programme	Extension workers		45
2017	Field demonstrations	Lead farmers	5	--
	Exhibition	Farmers and extension workers	500	20
	KVK Newsletter	Lead farmers and extension workers	15	275
	Television documentary	Farmers	500	--
	Farmer-scientist interface	Farmers	200	--
2018	Capacity building programme	Farmers	75	--
	Exhibition	Farmers and Extension workers	1300	15
2019	Method demonstration	Farmers	35	--
	Capacity building programme	Farmers	25	--
	KVK Newsletter	Lead Farmers and Extension workers	15	275
2020	Exhibition	Farmers and Extension workers	800	25
2021	KVK Newsletter	Lead farmers and extension workers	15	275

CONCLUSION

Although weevil was spotted in 0.12 % of plantains none of the 6685 plants sprayed with Nanma got damaged. 19.92% of crop damage was recorded in plantains treated with Chlorophyriphos and 45.6% of plantains got damaged fully in the control plot where no treatments were done. An average increase in bunch weight of 21.7% was recorded in the plants treated with Nanma over plantains treated chemically, while the same is at a high 55.9 % higher than that of plantains where no treatments were done. The district's average production of bananas is 7053 $Kgha^{-1}$, while, in the plantains treated with bio-pesticide nanma the average production is 21917 Kg ha^{-1}, which is almost 300 per cent higher. The yield increase was due to a reduction in crop damage. The technology was popularized through various extension methods. The production technology was purchased from ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, which commenced biopesticide production and supply to farmers.

Author contributions

Writing original draft - GM, MVR, IM, ST.

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