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Integrated pest management approaches to minimize incidence of cashew stem and root borers (*Plocaederus* spp.)

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Abstract

Cashew (*Anacardium occidentale* L.) trees infested by cashew stem and root borers (*Plocaederus* spp.) were treated with insecticides, entomopathogenic fungal spawn and neem oil after extraction of the pest stages in such trees, to prevent fresh infestation; referred to as 'post extraction prophylaxis' (PEP). Chlorpyriphos (0.2%) was identified as the most feasible PEP treatment in extensive field trials. Treatment with either neem oil (5 %) swabbing or application of *Metarhizium anisopliae* spawn (250 g/ tree) were proved to be ineffective in minimizing pest reinfestation, being on par with untreated control. Adoption of phytosanitation by removing the infested trees having more than 50 % bark circumference damage was proved to considerably reduce the number of trees having fresh pest incidence during the subsequent years. The pest population in a given location and also the pest load in infested cashew trees could be drastically reduced by adopting regular phytosanitation.

Keywords: Cashew stem and root borers, phytosanitation, *Plocaederus ferrugineus*, post extraction prophylaxis

Introduction

Among the various insect pests infesting cashew, cashew stem and root borers (CSRB) are a major source of concern as they seriously damage the yielding trees by tunneling the vital bark and out rightly kill the tree, if timely pest management is not adopted. This has led to severe depletion of tree density in all cashew growing tracts of the country, thereby diminishing the productivity. Pillai *et al.* (1976) reviewed the pest management in cashew and opined that CSRB could be managed by application of BHC 0.1 %. Chemical control of the pest using BHC 500 g/tree and monocrotophos as stem padding 15, 30 and 45 ml/tree was reported by Sundararaju (1985) from Goa. Prophylactic measures such as stem swabbing of carbaryl (0.25 %) in mud slurry was reported by Mohapatra (2004) while, Senguttavan (1999) suggested stem swabbing upto 1 m with BHC or using coal tar and kerosene swabbing four times in a year. Punnaiah and Devaprasad (1995) suggested placement of phorate granules as curative treatment for this pest incidence.

The extensive prophylactic trials conducted at National Research Centre for Cashew and in the cashew plantations of Karnataka Cashew Development Corporation, which comprised several additional treatments to the above, such as, polythene sheet wrapping on main stem and cement slurry swabbing on main stem and swabbing neem oil suspension, indicated inconsistency in their efficacy (NRCC, 1999). Further, the prophylactic treatments were labour and cost intensive.

Apart from chemical approaches for management of this serious pest, biological approaches viz., *Oryctes rhinoceros* virus was evaluated by Bakthavatsalam and Sundararaju (1990) and several species of entomopathogenic fungi, *Beauveria bassiana*, *B. brongniartii*, *Aspergillus niger*, *Aspergillus flavus* and *Metarhizium anisopliae* were evaluated by Bhat and Raviprasad (1995), NRCC (2003) and Ambethgar (2001) which induced insignificant field mortality. Hence this study was taken up with the purpose of identifying effective pest management strategies for management of cashew stem and root borers.

Materials and Methods

a) Post extraction prophylaxis (PEP)

The trials were conducted during 1997 to 2007 in different experimental plots of NRC-Cashew and plantations of Karnataka Cashew Development Corporation. The infested cashew trees were identified based on the external symptoms of infestation viz., oozing of the frass and gum from the collar, stem, exposed roots or fork region. The pest stages present in such trees were extracted by skillfully chiseling the infested portion of the tree and tracing out the pest stages in the tree. The frass and chipped materials from such trees were collected and disposed off. Later, the chiseled portion (main stem upto 1 m and on the exposed roots and fork of branches) was swabbed with the insecticidal solution to be evaluated. The same solution was drenched to the root zone, in case of root infestation. The insecticides evaluated were chlorpyriphos (0.2 %), monocrotophos (0.2 %) carbaryl (1.0 %) and lindane (0.2 %). In the trials under National Agricultural Technology Project (NATP), the spawn of the entomopathogenic fungus, *Metarhizium anisopliae* (250 g/ tree) and swabbing of neem oil suspension (5 %) were also evaluated. The untreated control comprised only removal of CSRB grubs without application of any insecticides. The treatments were applied sequentially to the trees from which the pest stages of CSRB were extracted. In the initial trials, all the trees infested by CSRB were treated with insecticides and due to negligible recovery in the trees having more than 50 % damage of bark circumference; only such trees having less than 50% damage of bark circumference were treated. The former were removed by uprooting as a phytosanitary measure.

The treatments were taken up during post monsoon months (November - March) and the trees showing symptoms of residual attack were given the earlier treatment after one month of initial treatment. Observations for fresh pest incidence were done at monthly intervals. The fresh pest incidence was made out by the presence of fresh frass exudation, which was much lighter in colour than the frass from older infestation. The percentage of treated trees without fresh infestation during the current season till onset of monsoon (June) was recorded. The number of trees treated under each treatment during 2003 was 55 under NATP evaluations and 40 under NRCC trials, while during 2004 the number of trees per treatment was 65.

Based on the results of earlier Post Extraction Prophylaxis (PEP) trials conducted during 2002-04, chlorpyriphos and monocrotophos which were significantly effective than swabbing of lindane (0.2 %), carbaryl (1.0 %), neem oil (5.0 %) and *M. anisopliae* spawn (250 g /tree) were further evaluated at 0.2, 0.4 and 0.6 % concentrations for their efficacy in subsequent trials during 2004-06.

b) Enhancement of spore load of *M. anisopliae* for management of CSRB

M.anisopliae spawn was applied as a prophylactic treatment at the base of healthy and infested cashew trees, along with cashew apple (250 g spawn + cashew apples 2 kg /tree) during 2001. Fresh incidence of CSRB on these trees as well as in the untreated trees was recorded. During 2002, *M. anisopliae* spawn was applied as a prophylactic treatment with boiled and cooled rice grits (250 g spawn + 2 l boiled rice grits) to enhance the substrate for fungal development. Soil samples were collected from the base of treated trees and CSRB grubs were allowed to crawl in these soil samples for six hours and the per cent infection of CSRB grubs was recorded.

Subsequently, during 2002, the same treatments were repeated along with imidacloprid (0.018 %) as a synergist and the residual action was evaluated by taking the soil sample after 90 days and allowing the CSRB grubs to crawl in it.

c) Evaluation of efficacy of phytosanitation

These trials were conducted during 2003 to 2006 in three different cashew plantations of Karnataka Cashew Development Corporation (KCDC), viz.,Koila, Alangaru and Sowthadka in Dakshina Kannada district of Karnataka, located more than 20 km from each other to avoid migration of the adult stages of the pest between the phytosanitation plots. The removal of pest stages from trees infested by CSRB and removal of trees having more than 50 % bark circumference damage by uprooting was adopted as a 'phytosanitary measure'. The number of trees (both healthy and treated) which showed fresh infestation symptoms during different months and the total number of CSRB grubs collected from these infested trees during the month were recorded. The mean number of freshly infested trees and the mean number of CSRB grubs per infested tree were worked out for each month and year.

Results and Discussion

a) Post extraction prophylaxis (PEP)

The post extraction treatments viz., carbaryl (1.0 %), chlorpyriphos (0.2 %), monocrotophos (0.2 %) and lindane (0.2 %) were on par in their efficacy in checking reinfestation by the pest, during 1999-2001 (Table 1).

Table 1. Efficacy of post extraction prophylaxis (PEP) on reinfestation (1999-2001) of cashew stem and root borer

Insecticide evaluated	Mean percentage of trees without re-infestation		Cost of insecticide treatment (Rs./tree)
Carbaryl (1.0 %)	65.0	74.6	12.80
Chlorpyriphos (0.2 %)	55.0	82.5	7.20
Monocrotophos (0.2 %)	70.0	60.6	4.56
Lindane (0.2 %)	75.0	77.4	3.00
SE m±	3.21	5.04	
CD (P = 0.05)	N.S	NS	--

N.S = Not significant

The severely infested trees having more than 50 % bark circumference damage could not recover in spite of these PEP treatments and hence, in the subsequent trials, only those trees having less than 50 % bark damage were selected for treatment. Chlorpyriphos (0.2 %) was the best PEP treatment with 96.43 % of infested trees without reinfestation, which was on par with monocrotophos (0.2 %) (78.57 %) in the NATP trial; it was significantly different from all other treatments under trials conducted at NRC-Cashew during 2003. Chlorpyriphos (0.2 %) showed the best efficacy as PEP treatment having 86.62 % of treated trees without reinfestation and was on par with lindane (0.2 %) (77.51 %) during 2004. The application of spawn of *M. anisopliae* or neem oil (5 %) swabbing were on par with the untreated control in NATP trials and were not evaluated further. Adopting only removal of CSRB grubs also led to reduced reinfestation, which was significantly the lowest compared to all other treatments (Table 2). Mohapatra *et al*. (2004) also reported 88.13 % of treated trees being free from reinfestation of CSRB with chlorpyriphos (0.2 %) treatment.

Table 2. Efficacy of post extraction prophylaxis (PEP) on levels of reinfestation by CSRB

PEP treatments evaluated	Mean percentage of trees without reinfestation		
	2003 (NATP)	2003 (NRCC)	2004
Chlorpyriphos (0.2%)	96.43^{a}	87.50^{a}	86.62^{a}
Monocrotophos (0.2%)	78.57^{ab}	61.25^{b}	70.83^{b}
Carbaryl (1.0%)	60.72^{b}	68.75^{b}	68.36^{b}
Lindane (0.2%)	70.00^{b}	60.42^{b}	77.51^{a}
M. anisopliae spawn @ 250g / tree	25.72^{c}	--	--
Neem oil (5.0%)	28.57^{c}	--	--
Untreated control (only removal of grubs)	22.47^{c}	48.46^{c}	47.17^{c}
CD (P = 0.05)	17.88	19.29	9.24

Note: Values followed by the same alphabet are not statistically significant

Under trials on investigating the comparative efficacy of the promising pesticides, chlorpyriphos and monocrotophos (both at 0.2, 0.4 and 0.6 % concentrations); chlorpyriphos (0.2 %) was on par with chlorpyriphos (0.4 %), monocrotophos (0.4 %) and (0.6%) during 2004-05. All the concentrations of chlorpyriphos were on par amongst themselves and with monocrotophos (0.4 and 0.6 %) during 2005-06. Considering the constant efficacy and cost of treatment (Rs. 7.20 / tree), chlorpyriphos (0.2 %) was identified for PEP treatment of CSRB infested trees, (Table 3).

Table 3. Percentage of trees without reinfestation by CSRB under PEP trials (2000-05)

Insecticides evaluated	Percentage of trees without reinfestation		Cost of insecticide treatment (Rs./ tree)
	2004-05	2005-06	
Chlorpyriphos (0.2%)	72.00^{b}	80.10^{ab}	7.20
Chlorpyriphos (0.4%)	76.00^{b}	81.68^{a}	14.40
Chlorpyriphos (0.6%)	96.00^{a}	85.76^{a}	21.60
Monocrotophos (0.2%)	56.00^{c}	68.06^{c}	6.00
Monocrotophos (0.4%)	72.00^{b}	72.90^{bc}	12.00
Monocrotophos (0.6%)	72.00^{b}	79.56^{ab}	18.00
Untreated control	28.00^{d}	26.88^{d}	--
CD (P=0.05)	12.61	8.67	--

Note: Values followed by the same alphabet are not statistically significant Cost of labour utilized for removal of pest stages followed by treatment ranged between Rs.16 to Rs.26 based on the severity of pest damage.

b) Evaluation of *M . anisopliae* as prophylaxis

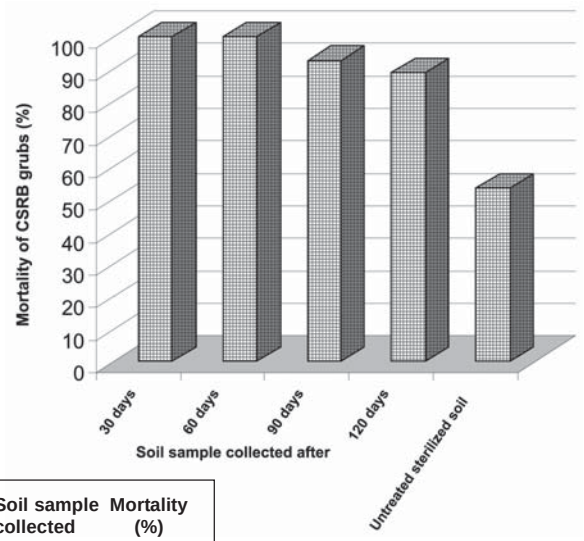
The fresh incidence of CSRB was 28.0 % on cashew trees treated with spawn of *M . anisopliae* alone during 2001. In untreated control, the fresh pest incidence was noticed in 16.7 % of the trees. In a subsequent trial during 2002, use of imidachloprid (0.018 %) could enhance the percent infection of CSRB grubs by *M. anisopliae* to 21.4 in comparison to *M.anisopliae* alone which led to 11.2 % infection (Table 4). Soil samples collected at 30 days intervals revealed that soil samples

Table 4. Effect of *M. anisopliae* as prophylactic treatment of CSRB

Treatment	2001 % of CSRB infested trees	2002 % infection of CSRB grubs	Mortality of CSRB grubs in soil samples, collected 90 days after application -2001 (%)
M. anisopliae alone	28.0^{a}	11.2^{b}	13.3^{a}
M. anisopliae + Imidacloprid	---	21.4^{a}	---
Untreated check	16.7^{b}	8.0^{c}	6.70^{b}
SEm±	1.21	---	1.43
CD (P = 0.05)	3.22	2.21	4.18

Note: Values followed by the same alphabet are not statistically significant

collected up to 120 days after application could induce mortality of CSRB grubs released in such samples. Mortality ranged from 100.0 to 88.9 % in such samples (Fig.1). The infection of CSRB grubs by *M. anisopliae* as well as residual toxicity of the entomopathogenic fungus did not show a consistent trend in these evaluations. Assessment of the efficacy of this entomopathogenic fungus under extensive field trials can confirm its field efficacy.

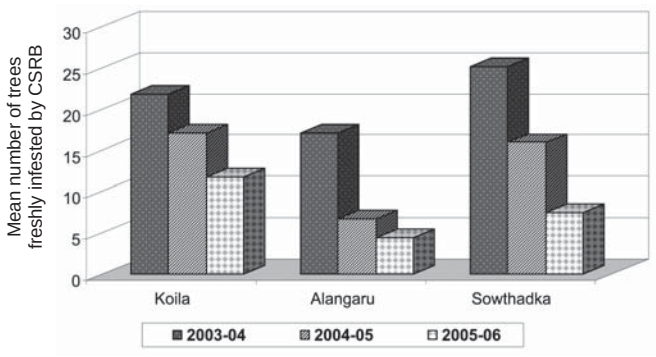


Soil sample collected after	Mortality (%)
30 days	100
60 days	100
90 days	92.6
120 days	88.9
Untreated sterilized soil	53.3

Fig. 1. Residual action of *M. anisopliae* on first instar grubs of CSRB

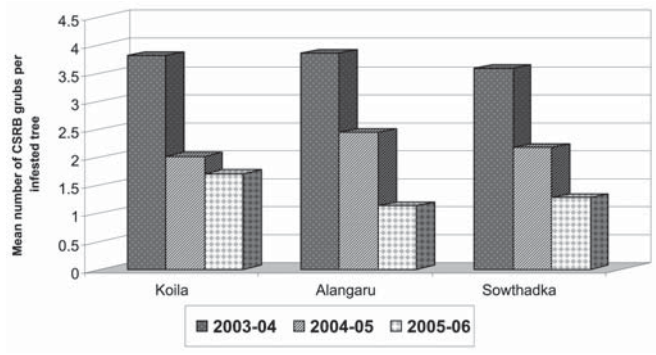
c) Evaluation of efficacy of phytosanitation

The mean number of cashew trees having fresh incidence of the CSRB during a year consistently decreased from a maximum of 25.17 during 2003-04 to 15.91 during 2004-05 and to a minimum of 7.50 during 2005-06 at Sowthadka (Fig.2). Similar trend was recorded at the other two plots located at Koila and Alangaru wherein the mean number of freshly infested trees decreased from 21.75 to 11.67 at Koila and from 17.08 to 4.42 at Alangaru from 2003 -04 to 2005-06. The mean number of CSRB grubs extracted per infested tree significantly decreased from a maximum of 3.86 during 2003-04 to 2.45 during 2004-05 and further decreased to a minimum of 1.14 during 2005-06 at Alangaru. Similar reduction in the mean number of CSRB grubs extracted per infested tree was recorded in the other two independently located plots viz., Koila and Sowthadka, wherein phytosanitation activity was adopted (Fig.3).



Years	Mean number of trees freshly infested by CSRB 2003-04	2004-05	2005-06
Koila	21.75	17.08	11.67
Alangaru	17.08	6.67	4.42
Sowthadka	25.17	15.91	7.5

Fig. 2. Mean number of cashew trees freshly infested by CSRB in plots with phytosanitation activity



Years	Mean number of CSRB grubs per infested tree 2003-04	2004-05	2005-06
Koila	3.82	2.02	1.71
Alangaru	3.86	2.45	1.14
Sowthadka	3.59	2.18	1.28

Fig. 3. Mean number of CSRB grubs per infested cashew tree in plots with phytosantiation activity

This trial confirmed the substantial reduction in the pest population in a given location and also a reduction in fresh infestation of cashew trees due to phytosanitation activity. Earlier reports on quantification of effect of phytosanitation on subsequent infestation by CSRB or other cerambycids are not available for comparison.

Conclusion

From the present studies, it can be concluded that chlorpyriphos (0.2 %) could be recommended for PEP treatment of CSRB infested trees. Further, this extensive study proves the need to adopt phytosanitation measures by removal of CSRB infested cashew trees which are

beyond recovery, to considerably reduce the pest population in a given location and also minimize the pest load in infested trees. Maintenance of optimal tree density can be achieved through adoption of post extraction prophylaxis (PEP) and phytosanitation for optimizing the productivity of cashew, by effectively managing this pest.

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