Research Article

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Validation of integrated pest management strategy against coconut rhinoceros beetle, *Oryctes rhinoceros* L. (Scarabaeidae: Coleoptera)

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Abstract

Juvenile palms in the age group of one to six years are prone to damage in the crown by rhinoceros beetle. Damage by the beetle results in 'V' shaped cuts in the leaf lamina and repeated attacks by the pest results in reduced leaf area for photosynthesis. Integrated pest management modules were developed for the management of coconut rhinoceros beetles and were validated under field conditions. Validation studies undertaken in three locations revealed that IPM practices including setting up of Rhinolure (PCI®) pheromone traps @ one per ha, field release of *Oryctes rhinoceros* virus suspension treated adults @ 15 per ha, placement of naphthalene balls @ 10 to 12 g per palm in the innermost leaf axil once in 45 days and application of green muscardine fungi, *Metarhizium anisopliae* to the manure pits during rainy seasons resulted in reduction in leaf and spindle damage to less than 10 per cent in all the locations tested. Site occupancy studies revealed the presence of virus infected *O. rhinoceros* and green muscardine fungus infected grubs in the manure pits adjacent to the experimental plots.

Keywords: Coconut, IPM, rhinoceros beetle, validation

Introduction

India is one of the three largest coconut producing countries of the world followed by Indonesia and the Philippines. Coconut is cultivated in an area of 20.9 lakh ha in India and has an average productivity of 10,614 nuts per ha (CDB, 2015-16). Among the various insect pests causing damage to coconut, rhinoceros beetle (*Oryctes rhinoceros* L.) is a serious pest in South East Asia (Bedford, 1980), infesting preferably young coconut palms in the age group of one to six years. The adult beetles cause injury to the young palms by boring into the spindle leaf, spathe and young petioles. An estimated yield loss of 10 per cent is attributed to spathe damage by rhinoceros beetles. The adult beetle feeds on the soft tissues and the chewed up fibrous material is seen protruding from the entry point or the bore holes (Nirula, 1955). The spindle leaf is thus prone to breakage and drying up. The damaged spindle leaf when unfurls exhibit "V" shaped cuts on the leaf lamina. Repeated attacks by the pest results in stunted growth or mortality (Hinckley, 1966; Giblin-Davis, 2001). In majority of the cases, rhinoceros beetle attack leads to infestation by red palm weevil, fungal infections, *etc*. (Sharadraj and Chandramohanan, 2013) causing death of the coconut palms (Molet, 2013). The female adults oviposit about 50 to 100 eggs, on the decaying logs of wood or manure pits (Bedford, 1980). The emerging larva survives in the manure pits or decomposing organic matter for three to six months. The adults upon emergence go in search of young palm crowns for feeding during night, while remaining in the breeding sites during day time. The adults live for another four to six months, during

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which it causes enormous damage to the younger palms. The pest could be kept under check by using varied options including cultural, mechanical, biological and chemical control measures. The present study is to validate the IPM measures for the area-wide management of rhinoceros beetles and to assess the impact of the IPM components in reducing the extent of damage caused by rhinoceros beetle.

Materials and methods

Field studies were conducted during 2010-12, 2012-13 and 2013-14 in three different locations in Anaimalai block of Coimbatore district *viz.,* Odayakulam, Semmanampathy and Avalchinnampalayam under All India Co-ordinated Research Project (AICRP) on Palms. An integrated pest management (IPM) module was followed incorporating all the IPM components in the selected gardens of approximately five hectare area. The gardens at Odayakulam and Semmanampathy were of WCT (3 to 4 years old) while the garden at Avalchinnamaplayam was 4 years old (var. Chowghat Orange dwarf). The IPM practices included setting up of Rhinolure (PCI®) pheromone traps @ one per ha, field release of *O. rhinoceros* virus suspension (virus culture from ICAR-CPCRI, Kayamkulam) treated adults @ 15 per ha, placement of naphthalene balls @ 10 to 12 g per palm (in perforated polythene sachets) in the innermost leaf axil once in 45 days, and application of green muscardine fungi (GMF), *Metarhizium anisopliae* to the manure pits during rainy and winter seasons. From each experimental plot, a total of 40 palms were randomly selected from five different spots (each spot with 8 palms). The per cent leaf damage was calculated based on the number of affected leaves out of total leaves in a palm, while the spindle damage was calculated based on the damage caused to the central spindle per palm.

The intensity of coconut rhinoceros beetle damage on leaf and spindle was recorded prior to imposing treatments and post treatment observations on leaf and spindle damage were recorded at six monthly intervals. The data obtained were subjected to appropriate transformation and analysed using paired 't' test. Site occupancy studies were also conducted in the manure pits in the vicinity of the experimental plots. A known quantity of grubs were collected from the pits and examined for the presence of symptoms of virus infection and mycelial growth or green sporulation on dead grubs (for GMF infested) and the incidence was expressed in terms of per cent incidence as follows:

$$\text{Per cent incidence of virus} = \frac{\text{No. of grubs showing virus infection symptoms}}{\text{Total number of grubs examined}} \times 100$$

$$\text{Per cent incidence of GMF} = \frac{\text{No. of grubs showing fungal mycelia growth/sporulation}}{\text{Total number of grubs examined}} \times 100$$

Table 1. Effect of IPM practices on the management of rhinoceros beetles

Period	Leaf damage (%)	Paired t	Spindle damage (%)	Paired t
Location I: Odayakulam				
Jan 2010 (pre-treatment)	42.5 (40.7)	-	22.5 (28.3)	-
June 2010	31.2 NS (33.9)	-	18.3 ** (25.4)	1.3
Dec 2010	22.0 NS (27.9)	-	10.8 * (19.2)	1.8
June 2011	14.5 ** (22.4)	23.7	6.7 ** (14.9)	2.5
Dec 2011	10.3 ** (18.7)	24.8	4.2 ** (11.8)	3.0
Location II: Semmanampathy				
June 2012 (pretreatment)	37.5 (37.8)	-	24.2 (29.5)	-
Dec 2012	28.0 NS (31.9)	-	19.2 * (25.9)	1.4
June 2013	11.1 ** (19.4)	13.0	8.3 ** (16.8)	2.4
Dec 2013	6.9 ** (15.3)	11.7	6.7 ** (14.9)	2.6
Location III: Avalchinnampalayam				
June 2013 (pretreatment)	42.9 (40.9)	-	56.7 (48.8)	-
Dec 2013	35.4 ** (3.5)	5.3	39.2 ** (38.7)	3.5
June 2014	11.5 ** (19.9)	11.3	10.8 ** (19.2)	7.8
Dec 2014	6.8 ** (15.3)	14.5	5.7 ** (12.4)	7.5

Values in parenthesis are arcsine transformed values
NS: Not significant; *Significant at 5% level; **Significant at 1% level

Results and discussion

The initial level of leaf damage at Odayakulam was 42.5 per cent. Up to 12 months, though there was a reduction in leaf damage, it was not significant. After 18 months, the leaf damage drastically reduced to 14.5 per cent ($t=23.7$; df 39, $p<0.01$) which further reduced to 10.3 per cent ($t=24.8$, df 39, $p<0.01$) at 24 months after treatment (MAT). During the same period, the spindle damage reduced from 22.5 per cent to 18.3 per cent at 6 MAT ($t=1.3$; df 39, $p<0.01$), 10.8per cent at 12 MAT ($t=1.8$; df 9, $p<0.05$), 6.7per cent at 18 MAT ($t=2.5$; df 39, $p<0.01$) and 4.2 per cent at 24 MAT ($t=3.0$; df 39, $p<0.01$).

A similar trend was noticed in the trials conducted at Semmanampathy village. At the time of initiating the trial the leaf damage was 37.5 per cent. After 12 months, there was a significant reduction in the leaf damage to the tune of 11.1 per cent ($t=13.0$, df 39, $p< 0.01$) which further reduced to 6.9 per cent ($t=11.7$, df 39, $p< 0.01$) at the end of 18 months. The spindle damage on the other hand was 24.2 per cent at the time of initiating the trial. The spindle damage showed a gradual and significant reduction periodically with 19.2 per cent at 6 MAT ($t=1.4$; df 39, $p<0.05$), 8.3 per cent at 12 MAT ($t=2.4$; df 39, $p<0.01$) and 6.7 per cent at 18 MAT ($t=2.6$; df 39, $p<0.01$). Reduction in spindle damage could be the result of the repellent action of naphthalene balls placed in the innermost leaf axils. Application of naphthalene balls at 10 g per palm at the base of the three top-most leaf sheath at 45 days interval helped in preventing rhinoceros beetle entry at crown region (Sadakathulla and Ramachandran, 1990) and they have attributed this phenomenon to the repellent action of naphthalene balls against adult rhinoceros beetles. A total of 53, 261 and 129 adult rhinoceros beetles were caught in the traps kept in Odayakulam, Semmanampathy and Avalchinnampalayam trial plots, respectively (Table 2). Reduction in fresh damage could also be attributed to the population load of adults causing damage at crown getting trapped in the pheromone traps kept in the garden. Studies on the efficacy of aggregation pheromone traps containing methyl-4-ethyloctonoate, in rhinoceros beetle management programmes has been suggested (Rajan *et al*., 2009; Chakravarthy *et al.,* 2014).The sex ratio of the adult beetles trapped in the present study revealed that the catches were female biased. This phenomenon provides a comparative advantage wherein trapping the female beetles would have a direct bearing on the population reduction.

The trials at Odayakulam and Semmanampathy were done on tall varieties while at Avalchinnampalayam, a dwarf cultivar, Chowghat Orange dwarf (COD) was used. The leaf and spindle damage was 42.9 per cent and 56.7 per cent, respectively, at the time of initiating the experiment. Upon imposing the components of IPM, there was a significant reduction (35.4%) in leaf damage at 6 MAT ($t=5.3$; df 39, $p<0.01$) which still reduced to 6.8 per cent ($t=14.5$; df 39, $p<0.01$) at 18 MAT. Simultaneously, the spindle damage also reduced to 5.7 per cent at 18 MAT ($t=7.5$; df 39, $p<0.01$). In all the trials, it could be observed that the reduction in leaf and spindle damage is more than 70 per cent at about 18 months of initiating the experiment. This could be due to the combined effect of the biocontrol agents *viz.*, GMF and *O. rhinoceros*-virus suspension which were slow acting and take time to establish in the ecosystem. In the site occupancy studies, up to 12.5 per cent incidence of virus infected *O. rhinoceros* adults were recovered from manure pits (Table 3). Infection by *O. rhinoceros*-virus suspension results in the active establishment of viral inoculums within the mid gut of the grubs and adults, the latter acting as 'flying reservoirs' infecting other adults during mating (Zelazny, 1976) or grubs in the breeding grounds which gets contaminated with the faeces of the affected adult beetle (Monserrat and Veyrunes, 1976; Mohan *et al*., 1983). Simultaneously, up to

Table 2. Trap catches in the trial plots

Trial location	Trap catches (numbers) from PCI traps (catches from 5 traps)			Sex ratio
	Females	Males	Total	(F: M)
Location I: Odayakulam	35	18	53	1.9: 1
Location 2: Semmanampathy	140	121	261	1.2: 1
Location 3: Avalchinnampalayam	73	56	129	1.3: 1

Table 3. Incidence of *Oryctes rhinoceros* virus and green muscardine fungi

Trial location	Incidence of *Oryctes rhinoceros* virus (%)		Incidence of green muscardine fungus (%)	
	6 MAT	12 MAT	6 MAT	12 MAT
Location I: Odayakulam	9.0	10.8	5.0	7.0
Location 2: Semmanampathy	6.7	9.1	5.0	12.5
Location 3: Avalchinnampalayam	5.6	12.5	5.3	14.3

MAT – Months after treatment

14.3 per cent incidence of GMF infected grubs were recovered from manure pits (Table 3). The efficacy of GMF at 5 x 10^{11} spores m^{-3} in the breeding sites has also been reported (Mohan and Pillai, 1982; Chandrika Mohan *et al.,* 2010).

Conclusion

Adoption of IPM practices in coconut would provide excellent reduction in rhinoceros beetle damage on leaves and spindles. Further, for effective results, it should be followed in a larger area through community-based pest management approaches.

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