Research Article

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Impact of area-wide extension approach for bio-management of rhinoceros beetle with *Metarhizium anisopliae*

P. Anithakumari*, K. Muralidharan[1] and Chandrika Mohan

ICAR-Central Plantation Crops Research Institute, Regional Station, Kayamkulam-695033, Kerala, India
[1]ICAR-Central Plantation Crops Research Institute, Kasaragod-671124, Kerala, India

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Abstract

Area-wide community extension approach (AWCA) was pilot tested for bio-management of rhinoceros beetle in Edava panchayat of Thiruvananthapuram district, Kerala state during the period 2010-2013. It focused on holdings having potential breeding sites of the pest and were treated with green muscardine fungus (GMF) *Metarhizium anisopliae* (Metsch.), multiplied at farm level by trained farm women groups. The project was implemented as participatory action research in an area of 520 ha of coconut involving over 5500 small and marginal farmers and stakeholders. AWCA proved to reduce the variability of technology impact in pest management compared to individual level of adoption. Significant reduction in the percentage incidence of rhinoceros beetles (72.9 ± 9.3 to 58.1 ± 9.3) was achieved in Edava panchayat whereas, it was more or less same (74.5%) during the period 2010-2013 in a non-intervention area (Kottamkara panchayat in Kollam district), where, only conventional extension approach was followed. Similarly, the average number of symptoms in coconut fronds per palm was also found to be reduced in AWCA area. It ranged from 1.6 to 4.6 before interventions and reduced to a range of 1.0 to 2.8 after interventions. In the non-intervention area, it remained almost same (2.9 and 3.0 cuts per palm, respectively in 2010 and 2013). Impact of AWCA was observed to be more or less geographically contiguous on depicting the percentage reduction in severity of rhinoceros infestation in different wards of Edava panchayat using GIS tools.

Keywords: Coconut, *Metarhizium anisopliae*, community, interventions

Introduction

Coconut (*Cocos nucifera* L.) is the base crop of the homestead farming systems in Kerala and many other regions in India. Majority of these holdings are in the category of small and marginal, which is inherently resource poor. It thus warrants appropriate social interventions and extension strategies for feasible, economically affordable, and effective technology integration and utilisation. This is more relevant in the case of pests and diseases management as the prevailing congenial conditions in one plot would definitely affect the neighbourhood plots, those farmers may even not realize that risk. For instance, consider the case of rhinoceros beetle (*Oryctes rhinoceros)*, a major pest of coconut in all coconut growing states in the country. The pest could cause an annual yield loss of 10 per cent in bearing palms and it infests seedlings and juvenile palms causing indirect economic losses. Infestation of rhinoceros beetles may also attract another serious pest, red palm weevil (*Rhynchophorus ferrugineus*). Rhinoceros beetles breeds on the debris and decayed organic materials. Even if one farmer practices all measures against its breeding, it is in vain, if the neighbourhood farmers do not follow such measures. Interestingly, the level of knowledge and adoption of bio-management practices against rhinoceros beetle was found to be very low among the farmers in spite of the technologies being recommended and transferred (Anithakumari *et al.*, 2012a). Non-availability of bio agents, low level of awareness about the bio-intensive practices and high cost and/or non availability of labour were the

*Corresponding Author: anithakumari.p@icar.gov.in

major constraints hindering the adoption (Anithakumari *et al.,* 2012b). For putting research into use and accelerating the pace of dissemination of bio-suppression of rhinoceros beetle, area-wide community extension approach (AWCA) was pilot tested and effectiveness of the social process was documented (Anithakumari *et al.,* 2015). This study further analyses the impact of AWCA in terms of effectiveness of technology dissemination and utilisation.

Materials and methods

The AWCA for bio-suppression of rhinoceros beetle was implemented as a participatory action research programme during 2010-2013 at Edava grama panchayath in Thiruvananthapuram district of Kerala state. Coconut was cultivated in an area of 520 ha in this panchayath, which is the principal crop in all the 17 wards (basic administrative units). To compare the effectiveness of AWCA over conventional extension approach, Kottamkara panchayat in Kollam district having almost same level of rhinoceros incidence was selected.

The community extension approach for enhancing the adoption and effectiveness of bio-management of rhinoceros beetle was focussed on holdings that are having potential breeding sites of the pest (*e.g*., holdings having livestock, coir pith heaps in coir processing units decaying coconut logs). The identified breeding sites were treated with green muscardine fungus (GMF) *Metarhizium anisopliae* (Metsch.) @ 100 g of culture in one litre water, multiplied at farm level by trained farm women groups. The treatment will be more effective during the rainy season or when the moisture and temperature level exists, which favours the fungal activity, for the bio-suppression of the pest. The basic methodology utilized for farm level multiplication of GMF was developed by Coconut Research Institute, Sri Lanka (2007). This was further modified by Mohan *et al*. (2010).

The conventional extension approach is individual farmer centric, and not distinguishing the 'potential' adopters, who are critical in AWCA. No concerted effort for bio-management of the pest was also practiced in those areas. Percentage of coconut palms having symptoms of damage due to rhinoceros beetle infestation, (the typical 'V-shaped' geometrical leaf cut), was taken as a measure of incidence and average number damaged leaves per palm as a measure of severity, since damage to spathe could not be observed in palms of the intervention area. Reduction in these measures was taken as a direct measure of impact of the community extension approach on bio-management of the pest. Since the damage symptoms were easy to detect, farmer participatory evaluation was attempted. A stratified sampling design with wards as strata was used. Within a ward, a single cluster of palms along the transect was taken as the sample. A similar sampling design was used in the case of non-intervention area with a modification that 6 out of 17 wards were selected at random for recording observations on palms along the respective transect. Data was recorded during March-April in the year 2010 (pre-intervention) and 2013 (post-intervention). In coconut palms, the symptoms of rhinoceros beetle attack could be observed in the fronds in the crown for a longer period, unlike in annuals.

For testing the effectiveness of interventions at ward level, 2 x 2 contingence table was constructed with pre- and post-intervention as factors with levels as 'presence' and 'absence' of pest infestation. McNemar test was employed for testing the significance of difference between pre- and post-intervention incidence. The estimates at ward level were aggregated to obtain percentage incidence at panchayath level. For comparing percentage incidence between the wards, t-test was used. The significance of reduction in the average number of damaged leaves in sampled palms of a ward was tested by means of paired t-test. The software SPSS v.19.0 was used for data analysis.

A measure of severity of the pest damage in a ward was obtained by multiplying total number of palms in that ward with percentage incidence and average number leaf cuts per palm. The percentage reduction of the severity measure was taken as the impact of AWCA at ward level and its geographical distribution was depicted in a map using ESRI-Mapping software. The map of Edava with ward boundaries and important land markings was used as source map. The scanned map was added in the Arc Catalogue and geo-referenced with 14 ground points (*e.g.* road junctions, railway gates, schools and other establishments) having known lat-long data. Digitized layers corresponding to panchayath boundary, ward polygons *etc.,* were created and severity measure was populated to the attribute table of ward polygons. For classification of wards according to severity, same class intervals were used for pre- and post-intervention data.

Results and discussion

The impact of the interventions in the panchayath area was furnished in terms of technology efficiency, technology dissemination, up scaling among categories of farm holding sizes, institutionalization models, and feedback from farming community for refinement of technology and palm level responses for evolving sustainability strategies for technology adoption. Total number of coconut palms in the wards (as available from a previous study), number of palms observed along the transect and percentage of infested palms in pre and post intervention periods are shown in Table 1. Prior to the project implementation, the percentage incidence of rhinoceros beetle (as observed from the symptoms present) was ranging from 50.6 to 91.9, while in the post-project period, the infestation was between 39.3 and 77.4 per cent. The McNemar test indicated that reduction in infestation was significant in 12 out of 17 wards of the project panchayath in a contiguous manner. Percentage reduction of infestation varied between 4.2 and 34.4. In seven wards, percentage reduction of infestation was more than 25.

The overall percentage infestation in the pre-project implementation period was estimated to be 72.9±9.3 and it was significantly decreased to 58.1±9.3 in the post-project period. In terms of number of infested palms in the panchayath, a reduction of 20.3 per cent was thus noticed as a result of AWCA (*i.e.,* number infested palms declined from 66342 to 52870). The five wards wherein non significant results was obtained with McNemar test *i.e.,* Wards 9, 12, 13, 15 and 17 recorded reduction of pest infestation at very low level compared to other wards. The lessons learned from this participatory action research were that the stakeholders in each sub-locality may not be same in terms of number, leadership, institutionalisation, vision and mission. Hence, for realizing area-wide response and impact of social interventions, these factors are to be mapped and considered for planning and implementation. On critical analysis of the field situation, it was found that the critical

Table 1. Reduction in rhinoceros beetle infestation after AWCA

Ward	Total no. of palms	No. of palms observed	Percentage incidence[1&2] Prior	Post	Percentage decrease	McNemar test of sig.
1	6559	100	64.0	42.0	34.4	0.000
2	7514	188	79.3	55.9	29.5	0.000
3	5509	111	91.9	72.1	21.6	0.000
4	4729	150	81.3	60.7	25.4	0.000
5	5544	112	86.6	75.0	13.4	0.002
6	6358	148	77.7	66.2	14.8	0.002
7	5515	116	75.0	55.2	26.4	0.000
8	5423	84	59.5	39.3	34.0	0.002
9	3178	31	87.1	77.4	11.1	0.250
10	4183	147	85.0	75.5	11.2	0.009
11	6952	83	61.5	43.4	29.4	0.006
12	3356	62	69.4	64.5	7.0	0.549
13	7308	89	50.6	47.2	6.7	0.648
14	4206	150	82.7	69.3	16.1	0.001
15	5764	55	65.5	52.7	19.4	0.143
16	4122	112	82.1	61.6	25.0	0.000
17	4810	79	60.8	58.2	4.2	0.804

[1] Chi-square test (Asymptotic; 2-sided) was significant in all the wards

[2] Paired t-test was significant in all the wards

Table 2. Reduction in severity of rhinoceros beetle incidence due to AWCA

Ward	No. of palms	Percentage incidence[*#] Prior	Percentage incidence[*#] Post	Percentage decrease	Mc-Nemar test of Sig.	No. of leaf cuts[#] Prior	No. of leaf cuts[#] Post	Per cent decrease
1	100	64.0	34.4	42.0	0.000	2.3	1.1	53.5
2	188	79.3	29.5	55.9	0.000	3.3	1.4	58.4
3	111	91.9	21.6	72.1	0.000	3.1	1.4	55.1
4	150	81.3	25.4	60.7	0.000	3.0	1.5	50.5
5	112	86.6	13.4	75.0	0.002	3.5	1.3	62.6
6	148	77.7	14.8	66.2	0.002	2.8	1.4	47.8
7	116	75.0	26.4	55.2	0.000	3.7	1.2	66.2
8	84	59.5	34.0	39.3	0.002	2.1	1.1	48.8
9	31	87.1	11.1	77.4	0.250	4.6	2.8	39.3
10	147	85.0	11.2	75.5	0.009	3.0	1.5	51.0
11	83	61.5	29.4	43.4	0.006	2.0	1.3	36.2
12	62	69.4	7.0	64.5	0.549	2.5	1.9	26.9
13	89	50.6	6.7	47.2	0.648	1.6	1.0	34.6
14	150	82.7	16.1	69.3	0.001	3.9	1.7	56.5
15	55	65.5	19.4	52.7	0.143	2.3	1.2	49.8
16	112	82.1	25.0	61.6	0.000	2.7	1.3	54.0
17	79	60.8	4.2	58.2	0.804	2.2	1.5	32.1

[*]Chi-square test (Asymptotic; 2-sided) was significant in all the wards
[#]Paired t-test was significant in all the wards

adopters in these wards (livestock farmers) were limited in numbers and scattered compared to other wards. Hence the involvement of livestock farmer's cooperative societies could not be elicited as expected in all the wards, except in their area of operation. Hence this experience teaches the need for adopting refined strategies in locations with specific situations keeping the basic principles of the approach. It warrants for group approach among the coconut farming community in technology integration of other recommended practices along with bio-management practices.

Prior to implementation of the project, number of leaves with typical v-shaped cuts due to rhinoceros beetle infestation was between 1.6 and 4.6 per palm (Table 2). Observations made in the pre and post-project period was subjected to paired t-test which was significant in all the wards. Number of damaged leaves varied from 1.0 to 2.8 per palm in the post-project period. Percentage reduction varied between 32.1 and 66.2. Severity of the pest incidence, worked out as a product of estimated number of palms in the ward and number of leaves showing damage, is also shown in Table 2. In terms of this measure of severity, highest reduction was noticed in ward 7 (75.1%) and lowest in ward 12 (32%). The impact was not uniform among the wards (Fig. 1). More than 60 per cent reduction was between 40 and 60 per cent and in the remaining three wards; it was between 30 and 40 per cent. The impact of AWCA was more or less geographically contiguous; exception was in two wards *viz.,* 15 and 17. Technology adoption could be widely spread among the farming community through this approach and realized faster dissemination, and integration of environment friendly, simple and effective recommended technologies with traditionally proven practices such as prophylactic leaf axil filling with salt, sand and ash mixture and incorporation of *Clerodendron infortunatum* in the breeding sites of rhinoceros beetles. Vargas *et al.* (2007), in their report on area wide fruit fly management programme at Hawaii, indicated 30-50 per cent reduction in pest incidence after the interventions, along with improved collaborations at international levels. In the traditional extension approach for management of rhinoceros beetle, in farmers plot, longer duration, extensive travel and expenses were required besides the effort for convincing farmers of varied interest,

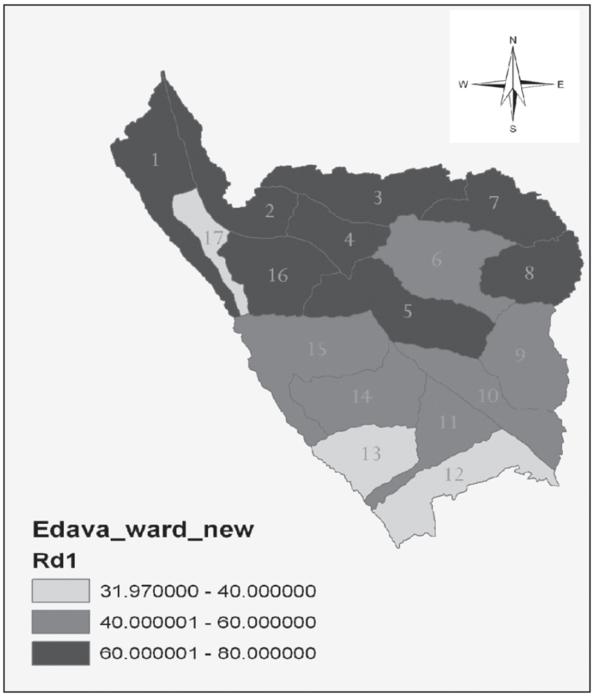

Fig. 1. Impact of AWCA in the geographical area of the Edava panchayath (Intervention area)

resources and risk bearing capacity. Scope for unintentional transmission of benefits among farmers is also an impact in this approach. Rather than individual crop, community management of contiguous area possible in the case of pests like rhinoceros beetles occurring in majority of the farmers' fields.

The major gain recorded by the farmers who participated in the study was the low cost, less drudgery and environment and farmer friendliness.

Table 3. Incidence of rhinoceros beetle in coconut palms in non-intervention area during corresponding period of interventions (Kottamkara panchayath, Kollam district)

No. of palms observed	Percentage incidence		Average number of V- shaped leaf cuts per palm	
	2010	2013	2010	2013
79	77.2	82.3	2.7	3.2
51	74.5	71.7	3.5	3.4
60	65.0	66.7	2.6	3.0
72	68.1	69.4	2.4	2.9
55	78.2	79.4	2.6	2.7
80	88.8	81.3	3.7	3.4
63	69.8	71.4	2.5	2.6

The area wide approach further strengthened its utility in reduction of efficacy of the technologies across the system of intervention compared to the household or individual level technology adoption. The extension approach facilitated overcoming the major challenges of fragmented holding of coconut cultivation in terms of its perennial nature, effective and purposeful linking of stakeholders, targeting critical adopters to improve reachability to large area with lesser time. When compared to individual level adoption, farmers opined 70-80 per cent reduction in cost of technology adoption. Garcia-Pabon and Lutch (2009) showed that effective delivery of IPM information to potential users required careful assessment of the target users and a commitment of resources and support on a long term, as the case in this study also.

Impact of AWCA – analysis of non-intervention area

The area-wide impact of the community adoption approach was very clear in the data collected correspondingly in a non intervention area of Kollam district. The next district was selected to avoid any kind of collateral influence due to proximity. The data were collected from seven wards, from about 460 coconut palms. The data is furnished Table 3.

Unlike in the project area, percentage incidence of the pest has not significantly declined in the non-intervention areas (Table 3). Rather, it was the same during 2010 and 2013 (respectively 74.5 and 74.6%) In none of the selected wards, the average number of typical v-shaped cuts in fronds by the rhinoceros beetle was found to be significantly different. Average number of v-shaped cuts per palm in the panchayat was 2.9 (in 2010) and 3.0 (in 2013). This strongly indicated the superiority and effectiveness of the AWCA in reduction of pest incidence across the varied social systems and palm profiles, across a contiguous geographical area, and could be integrated with other management technologies for better and wider observable results.

In the case on non-bearing juvenile palms, the increase in the average number of typical v-shaped cuts in fronds by the rhinoceros beetle was found to be increased from 2.1 to 2.5 cuts per palm during the corresponding project period, compared to reduction in intervened area and the contrary in case

Table.4. Infestation pattern of rhinoceros beetle incidence in intervention and non-intervention area

Infestation pattern	Adult palms (%)		Juvenile palms (%)	
	Intervention area[1]	Non-intervention area[2]	Intervention area	Non-intervention area
Absence	13.2	12.3	9.2	26.0
Increased	6.1	42.6	7.7	38.4
Decreased	71.4	35.9	73.1	27.4
No change	9.4	9.3	10.0	08.2

[1]Edava gramapanchayath, Thiruvananthapuram district
[2]Kottamkara gramapanchayath, Kollam district

of seedlings, which requires further analysis and observations. The reduction of pest incidence in terms of average number of typical v-shaped cut symptoms was highest among adult bearing palms compared to non-bearing juvenile palms. But, reduction in pest incidence was recorded in both categories in intervention area (compared to increase in pest incidence in adult bearing and non-bearing palms in the non-intervened area) indicated clearly the relative advantage of area-wide community level technology adoption. The comparative higher level of pest incidence in seedlings of intervention area calls for further studies and analysis considering that they are more prone to attack. It also warrants systematic adoption of prophylactic measures in seedlings while going for area-wide community approach. Differences in production methods used and perceptions of the information sources considered valuable by such a diverse group of producers including resource limited farmers (Ngathou *et al*., 2006), create distinct challenges for extension personnel (Kline *et al.,* 2012), which is very much applicable to the coconut farming situations for evolving pest management strategies.

Sustainability of community based technology adoption

The pest incidence and field situations of coconut based farming systems are dynamic, continuous and interlinked in pattern. Bio-management of rhinoceros beetle incidence involves stakeholder participation, decentralized production of bio-agent (*Metarhizium anisopliae)* and feedback of community members for improving efficiency of technology utilization. The pattern of pest incidence of intervention and non-intervention areas indicated need for community adoption of bio-management package for sustainable results. Table 4 shows the existence of pattern of pest incidence in actual field conditions, in intervened and non-intervened areas.

While recording and analysing the observations before and after interventions, it could be noticed that there were four categories of pest incidence pattern in coconut gardens. Almost 10 per cent of the palms sampled did not show any change in pest incidence before and after interventions, in both intervention and non-intervention areas, irrespective of adult or juvenile stage. Whereas, 9 per cent of adult and 13 per cent of juvenile palms of intervened area and 12 per cent of adult and 26 per cent of juvenile palms of non intervened area, showed absence of symptoms after intervention period, which may be the indication of natural resistance of palms to rhinoceros beetle infestation. The data also indicated low rate of increase in pest incidence and high level of decreased incidence in intervened area compared to non intervened area. Periodic surveillance could provide the pattern of pest incidence and thus scheduling the frequency of AWCA. It also pointed towards the need for evolving threshold levels for community adoption approaches of pest management in coconut.

Community feedback for field level refinement in technology adoption

The women self-help group and master trainers of farm level production of green muscardine fungus (GMF) not only made available the bio agent in the project area, but also multiplied and supplied to other five districts (providing 5000 packets of GMF) employing farm level production method using simple, low cost and efficient model. Over the years, the group trained more than 2300 farmers in farm produce processing and community management of rhinoceros beetle. They further refined the multiplication procedure reducing 50 per cent cost and 40 per cent of time. Another major feedback from farming community was to reduce frequency of treatment of rhinoceros beetle breeding sites from once in two years to once in a year based on their observation and experience of adopting the technology. They noticed that the fungus did not service or infect grubs during the summer months when the cowdung was removed for seasonal intercrops, leaving only a portion of treated organics as recommended, and needs replenishment every year.

The most remarkable outcome was the improvement in technology access and social role of rural women farmers in dissemination due to community extension approach along with empowered participants. An up-scalable participatory model for AWCA was put forward and replicated in 6000 ha of coconut area achieving reduction in rhinoceros beetle incidence. Varied adoption by individual farmers reduced efficiency of rhinoceros beetle management in perennial palm crop like coconut cultivated mostly in small and marginal holdings, in a continuous fashion. Hence, area-wide community extension approach coordinated by groups, proved to bring down individual garden based variability and significantly reduced pest incidence throughout the area of intervention. It was also found that the GMF technology could be integrated with existing recommendations and appropriate for area-wide adoption, ensuring continuous adoption. Experience and observations proved that area-wide impact indicated feasibility of technologies in pest reduction, wider dissemination within 2-3 years compared to individual extension approaches. Multi stakeholder alliance based communication plans are needed for regional agricultural goals than isolated projects. It was also learned that area-wide management is effective when organized against single pest offering long term solutions employing biologically based management strategies. Putting research into efficient use is a major challenge and technology/problem specific extension approaches provides pathways towards the goal.

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References

Anithakumari, P., Muralidharan, K., Kalavathi, S. and Remabai, S. 2012a. Constraints in adoption of integrated management for root (wilt) disease affected areas - An analysis of Alleppey district. *Journal of Plantation Crops* **40**(1): 9-15.

Anithakumari, P., Muralidharan, K. and Kalavathi, S. 2012b. Technology utilization among coconut farmers of root (wilt) disease affected areas. *Journal of Plantation Crops* **40**(3): 174-180.

Anithakumari, P., Muralidharan, K. and Kalavathi, S. 2015. Community extension approach in bio-management of rhinoceros beetle, the major pest of coconut. *The Indian Research Journal of Extension Education* **15**(1): 70-75.

CRI, Sri Lanka. 2007. On farm production of green muscardine fungus for management of black beetle. Crop Protection Division, Coconut Research Institute, Sri Lanka, March 2007. 10 p.

García-Pabón, J.L. and Lucht, J.R. 2009. Latino farmers in Missouri: Risks, services, and implications for Extension. *Journal of Extension* [On-line], 47(4) Article 4FEA3. Available at: http://www.joe.org/joe/2009august/a3.php

Kline, T.R., Kneen H., Barrett, E., Kleinschmidt, A. and Doohan, D. 2012. Adapting extension food safety programming for vegetable growers to accommodate differences in ethnicity, farming scale, and other individual factors. *Journal of Extension* [On-line], 50(1) Article 1IAW1. Available at:http://www.joe.org/joe/2012february/iw1.php.

Mohan, C. Rajan P., Nair, C.P.R., Thomas, S. and Anithakumari, P. (2010). Farmer friendly production technology of the green muscardine fungus for the management of rhinoceros beetle. *Indian Coconut Journal* **33**(7): 27-31.

Ngathou, I.N., Bukenya, J.O. and Chembezi, D.M. 2006. Managing agricultural risk: Examining information sources preferred by limited resource farmers. *Journal of Extension* [On-line], 44(6) Article 6FEA2. Available at: http://www.joe.org/joe/2006december/a2.php

Vargas, R.I., Mau, R.F.L. and Jang, E.B. 2007. The Hawaii fruit fly area-wide pest management program: Accomplishments and future directions. *Proceedings of the Hawaiian Entomological Society* **39**: 1-6.