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Control of Papaya Mealybug in Cassava at Namakkal District, Tamil Nadu: A Successful Model of Research- Extension- Farmers Linkage

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Abstract

Ninety five per cent of the area under cassava in Namakkal district, Tamil Nadu, was severely affected by the papaya mealybug (*Paracoccus marginatus*) during 2010-2012. The Krishi Vigyan Kendra (KVK), Namakkal of the Tamil Nadu Veterinary and Animal Science University (TANUVAS) established a laboratory for the mass multiplication of the parasitoid (*Acerophagus papayae*) for the control of papaya mealybug during January 2011 under the scheme sponsored by Agricultural Technology and Management Agency (ATMA), Namakkal. The parasitoid was successfully mass multiplied in the laboratory of the KVK on *Paracoccus marginatus* colonies by three methods (i) on sprouted potato tubers (ii) on cassava leaves and (iii) on papaya leaves and fruits. Of the three methods, the second instar papaya mealybug infested cassava leaves were found to be very suitable for intensive production of parasitoid in a short period of time. The parasitoids were inoculated on mealy bug infested (second instar larvae) cassava leaves brought by farmers of Namakkal in white plastic boxes and incubated for 15–20 days. The hatched parasitoids were distributed to the farmers with the help of officials from the Department of Horticulture, Namakkal. A total number of 4,44,560 parasitoids were supplied to 2437 farmers covering 3743.2 ha of cassava field. Control of mealybug infestation was noticed from 45 days after the release of parasitoid and complete eradication of the pest could be achieved by the end of six months. There was no mealybug incidence by 2014. Nearly 10 – 15% of parasitoids were found in non host plants.

Key words: Cassava, papaya mealybug, parasitoid, mass multiplication, research-extension- farmers linkage

Introduction

The papaya mealybug, *Paracocous marginatus* (Williams and Granara de Willink) (Hemiptera: Pseudococcidae) is a serious pest of papaya (Williams and Granara de Willink, 1992). Besides papaya, other important hosts recorded are cassava, citrus, mango, avocado, tomato, eggplant, pepper, beans, peas, sweet potato, cotton, hibiscus, cherry, pomegranate, rubber etc. (Miller and Miller, 2002; Heu et al., 2007). Classical biological control was identified as an important component in the management of *P. marginatus* (Walkar et al., 2006). The introductions of *Acerophagus papayae* Noyes and Schauff, *Anagyrus loekii* Noyes and *Pseudleptomastix mexicana* Noyes and Schauff parasitoids were found successful wherever the pest invaded (Noyes and Schauff, 2003; Meyerdirk et al., 2004). Among the three parasitoids, *Acerophagus papayae* was found to be an efficient parasitoid for the suppression of papaya mealybug in its native range and has the ability to establish itself when introduced to new localities (Amaraskare et al., 2008 ; Amaraskare et al., 2009; Muniappan et al., 2006).

The papaya mealybug had become serious on cassava in Namakkal district of Tamil Nadu during 2010 -2012. In this district, cassava is cultivated in an area of 15,000 ha. The major varieties of cassava under cultivation were Mulluvadi in all blocks, White Rose and Kunguma Rose in Sendamanagalam block, Sree Vijaya in Namagiripettai and Rasipuram blocks, H-226 in Thiruchengode and Elachipalayam blocks. Ninety five percent of area under cassava was severely affected by papaya mealybug.

Mealybug affected seven months old cassava plants at tuber maturation stage and the symptoms were noticed on the stem portion, leaf petioles, terminal leaves and underside of the leaves. Infestation of the mealybug appeared as clusters of cotton like masses on the above ground portion of plants with long waxy filaments. Immature and adult stages of mealybug sucked the sap of the plant and weakened it. The leaves became crinkled, yellowish and later withered. The honey dew secreted by the bug and the associated black sooty mould formation impaired the photosynthetic efficiency of the affected plants. Its short life cycle, more generations per year, higher fecundity, easy dispersal, protective mealy coating etc., helped the pest to multiply in enormous population (Shylesha et al., 2010). In Sri Lanka, the parasitoid *Acerophagus papayae*, resulted in complete control of the mealybug within a year of release of the parasitoids (Galanihe et al., 2010). Similar results were reported by Rabindra and Shylesha (2011) in papaya in Erode and Coimbatore districts of Tamil Nadu.

At the Grievances Meet held at Collectorate, Namakkal, during December 2010, the farmers had sought bulk production of the parasitoid to put an end to the mealybug menace that had hit close to 90% of the cassava cultivation in the district. The district collector assigned the work on mass multiplication of parasitoid to KVK, Namakkal. District administration sanctioned adequate funds through ATMA to carry out research and find out the best method for mass multiplication of parasitoid at KVK, Namakkal.

Keeping in view of the aforementioned facts, Krishi Vigyan Kendra (KVK), Namakkal established a laboratory for the mass multiplication of parasitoid for the control of mealybug. The objectives of the present study were (i) to assess the best method for mass multiplication of parasitoid (ii) intensive production and immediate control of papaya mealybug infestation in cassava through research-extension-farmers linkage.

Materials and Methods

Tamil Nadu Veterinary and Animal Science University (TANUVAS), KVK, Namakkal, established a laboratory for the mass multiplication of the parasitoid for the control of papaya mealybug during January 2011. The scheme was sponsored by Agricultural Technology and Management Agency (ATMA), Namakkal. The parasitoid was mass multiplied successfully in the laboratory on papaya mealybug colonies by three methods i) on sprouted potato tubers (ii) on cassava leaves and (iii) papaya leaves and fruits and the efficiency and establishment of *A. papayae* on *P. marginatus* under Namakkal conditions was assessed.

1. Mass multiplication of parasitoid on sprouted potato tubers

A colony of *P. marginatus* was maintained on 15 kg of sprouted potato under laboratory conditions. Initially, *P. marginatus* was collected from papaya and cassava fields from Namakkal district. The potatoes sprouted in 18-20 days after planting. Each week, 35 sprouted potatoes were infested with *P. marginatus* ovisacs (each potato with 3–5 ovisacs). This method took approximately 45 days for the multiplication of the parasitoid. In this method nearly 600-1000 parasitoids were produced per week and 50 parasitoids were supplied per farmer.

2. Mass multiplication of parasitoids on cassava leaves

Considering the quantity of parasitoids required to cover 3743.2 ha, the time required for the multiplication and the limited production capacity of the first method, mass multiplication at laboratory level was accomplished by the cassava leaves infested with second instar larvae of *P. marginatus* as *A. papaya*e preferred second instar of *P. marginatus*. In this method, nearly 18-20 leaves were placed in white plastic boxes. For each box, 50 parasitoids were released. After that, a piece of cotton wetted with solution of honey and water (1:1 ratio) was placed on the inner side of the box in four places. Then, the mouth portion of the box was covered with kada cloth. Name and address of the farmer and the date of release of the parasitoid into the box were mentioned in the label of the box. The boxes were arranged in a steel rack, wherein each rack contained 40 boxes. Water was provided in four stainless silver cups of 50 ml capacity per table and

it was placed below the leg portion of the rack to prevent entry of ants. Five days after the release of the parasitoid, fresh cassava leaves infested with second instar larvae were placed in the box. By this method, parasitoid multiplied @ 170 -200/box in 12 -22 days.

3. Procedure for mass multiplication of parasitoid on papaya fruits

Immature or mature but unripe fruits of papaya without latex, affected by mealybug, which was in second instar larval stage were used for the parasitoid multiplication. In this method, the papaya fruit was placed in a plastic container and the parasitoid was released into the container @ 50 per box. Then a piece of cotton wetted with honey was placed inside the container @ 2 numbers per container. After that the mouth of the container was covered with muslin cloth. The parasitoid devoured the mealybug in 5-7 days. The first instar larvae of parasitoid hatched out within a week.

The weather parameters were also recorded at automatic weather station of KVK, Namakkal to find out the effect of weather parameters on the development of the pest and parasitoid. The best method for the mass multiplication of the parasitoid was assessed and intensive production and immediate control of papaya mealybug infestation in cassava through research-extension-farmers linkage were undertaken.

Results and Discussion

Effect of weather parameters on the development of pest and parasitoid

Temperature is one of the important abiotic factors that may decide the establishment and distribution of papaya mealybug (Huffaker et al., 1999). At temperatures between 20 and 25°C, the papaya mealybug showed complete development within 36 to 46 days (Lema and Herren, 1985). The maximum development of *P. marginatus* was found to be at 28°C – 32°C. In Namakkal district, the establishment of *P. marginatus* was more vulnerable in Tiruchengode, Mallasamuthiram, Elachipalayam, Namagiripettai, Sendamangalam and Rasipuram blocks during January–June 2011. It might be due to the prevalence of high temperature from 31.1 to 38.6°C and existence of favourable relative humidity (50-70%) (Table 1). Hence, *Paracoccus marginatus* successfully developed, reproduced and survived on a number of varieties of cassava. This is in accordance with the findings of Venkatesan et al. (2011).

The developmental period of the parasitoid is also affected by the temperature (Amarasekare et al., 2011). *Acerophagus papayae* had shorter developmental period for both males and females. When the developmental period of a parasitoid is shorter than the developmental period of the host, there is an advantage for the parasitoid. The developmental period increased with increasing temperature. The parasitoid development was minimum during the month of February-May 2011. During summer months (February–May) the parasitoid hatched out within 20–22 days. It might be due to the prevalence of high temperature (33 – 38.6°C). Similar result was also reported by Amarasekare (2007). It is normally recommended to release 50 parasitoids per acre. Since mealybug menace was maximum and the parasitoid took longer time to hatch during summer months, we advised to release the parasitoid @ 500 per hectare to control the mealybug infestation effectively. On the contrary, the parasitoid hatched out within 12-15 days during June-November. In addition, due to high wind speed the parasitoid easily dispersed from one field to another during June-November 2011.

Table 1. Weather parameters recorded during the study period at KVK,Namakkal

Month (2011)	Temperature (°C)		Relative humidity (%)		Wind speed (km h^{-1})		Rainfall (mm)
	Maximum	Minimum	Maximum	Minimum	Morning	Evening	
January	31.7	19.4	73.3	37.2	1.61	3.3	0
February	33.0	19.4	73.0	45.8	2.1	3.8	23.7
March	31.1	21.6	69.0	39.0	2.0	3.8	0
April	36.0	24.2	67.9	43.3	2.57	3.2	145.4
May	38.6	24.8	67.7	56.1	2.4	2.8	55.5
June	31.1	25.3	72.67	51.2	4.8	10.0	3.0

Method for mass multiplication of the parasitoid

Out of the three methods used for the mass multiplication of the parasitoid, the second instar papaya mealybug infested cassava leaves were found to be very suitable for intensive production of parasitoid in a short period of time. This might be due to the presence of maximum number of second instar larvae of mealybug on cassava leaves that facilitated the maximum parasitization of papaya mealybug by *A. papayae*. This is in conformity with the findings of Sankar et al. (2012). In the field after the release of the parasitoid the mealybug was controlled in 40 days.

In the field, per cent parasitization gradually increased from the time of release until full control of mealybug was attained. Because under the field conditions, various stages of mealybugs existed. But the parasitoid preferred only the second instar larval stage of mealybug. So, the parasitoid gradually controlled the mealybug menace in cassava. Further, these parasitoids recovered from *P. marginatus* and established in other hosts. So, the parasitization occurred in both released and non released fields. The present result was similar to the findings of Ragupathy and Ayyasamy (2012) and the parasitoid was the main contributor to the mortality (95%) of this mealybug in cassava. Our findings also confirmed that the papaya mealybug incidence in cassava under field conditions was reduced up to 95% in 2010-2011, which became 100% in the following year within 5 to 6 months after the introduction of the parasitoids. Similar results have been noted in the Dominic Republic, Puerto Rico and Guam with about 97% reduction in papaya mealybug population a year after the release of the parasitoids (Meyerdirk and Kauffman, 2001; Meyerdirk et al., 2004). In 2013-2014, 57 ha of cassava at Erumapatti and Namagiripettai blocks of Namakkal district were affected by mealybug. Initially, the parasitoids collected from papaya field of Mohanur block were released, and then 47 farmers from both the blocks were trained for the multiplication of parasitoid and 28,500 parasitoids were released. There was no mealybug incidence by 2014. Nearly 10–15 per cent of parasitoids were found in non host plants

In addition, in Namakkal district cassava is cultivated throughout the year as a rainfed as well as irrigated crop. Hence most of the parasitoids were found not only in cassava but also in alternate host plants viz., papaya, parthenium and hibiscus. So, the parasitoid found in the non host plants effectively controlled the mealybug, when the incidence was very low. Moreover, in this district, cassava is the major crop in all blocks, except Erumapatti and Mohanur block, where multiplier onion and banana are the major crops respectively. The farmers also had awareness about the effect of parasitoid on mealybug. So, the pesticide spray was not done against mealybug in cassava field. Hence, the survival of parasitoids increased in the non host plants.

Research-extension-farmers linkage

The research-extension-farmers linkage is given in Table 2. After identification of the best method for mass multiplication of parasitoid in a short period of time, mealybug affected cassava farmers were requested to register their details block wise by the concerned Horticulture Department officials. Then farmers from 15 blocks of Namakkal district were requested to bring the mealybug infested (second instar larvae) cassava leaves in a white plastic box. They handed over the boxes to KVK, Namakkal, after entering their names, addresses, area of cassava cultivation, stage of the crop, variety of

Table 2. Research-extension-farmers linkage/convergence

Year	Name of the scheme	Sponsored by
2010	Front Line Demonstration on biocontrol method of papaya mealy bug in cassava	ICAR, New Delhi
2010	ATMA–Researchable issues–Mass production of parasitoid against papaya mealybug	ATMA, Namakkal
2011	Farmers-Scientists Interaction Meets on mass multiplication and distribution of parasitoid for the control of papaya mealybug in cassava	ATMA, Namakkal
2011	Mass multiplication of parasitoid	ATMA, Namakkal
2011	Farmers training on mass multiplication of parasitoid for the control of papaya mealybug	ATMA, Namakkal

cassava and dates in the boxes . The parasitoids were released into the boxes and incubated for 12–22 days, depending upon the multiplication rate. The hatched parasitoids were distributed to the farmers with the help of the officials from the Department of Horticulture, Namakkal in 24 phases. Method of release of parasitoid was properly demonstrated by KVK as well as line department officials. Totally 4, 44, 560 number of parasitoids were supplied to 2437 farmers covering 3743.2 ha of cassava field in 24 phases.

Resource farmers for the multiplication and supply of parasitoid

Ten resource farmers were trained on the method of rearing of parasitoid at KVK, Namakkal and they supplied the parasitoid by the following method viz., culture the parasitoid in plastic boxes using cassava leaves in 10 days and provide cassava leaves containing parasitoid in the boxes readily. Apart from KVK, the resource farmers also supplied 1,97,300 parasitoids to 1075 farmers covering an area of 1398 ha of cassava field in Elachipalayam, Namagiripettai, Sendamangalam and Mallasamuthiram blocks of Namakkal district.

The economic impact

The main inputs for papaya mealybug parasitoid production on potato sprout were potatoes, laboratory consumables, labour especially for collection and distribution of parasitoids. Thus, for the production of 20,000 parasitoids using potatoes, the approximate cost was Rs. 9000– 9200, whereas mass multiplication done using cassava leaves was cost effective as the major inputs like honey, labour and kada cloth cost Rs. 1000.

The farmers were able to get an yield of 30-37.5 t ha^{-1}, income of up to Rs.50,000 ha^{-1} and savings of up to 10, 250 ha^{-1}, since pesticides were not used. The parasitoids thus released perpetuated and multiplied in large numbers under field conditions and spread enormously and very rapidly to the neighbouring fields and it was not harmful to the beneficial insects.

Conclusion

In Namakkal district, Tamil Nadu, the outbreak of papaya mealybug could be brought under control successfully in hot spot areas after mass multiplication and release of parasitoid by Krishi Vigyan Kendra by adoption of specific tool viz., research–extension-farmers linkage. This is a successful model of research-extension-farmers linkage in the biocontrol of the papaya mealybug in cassava.

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