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Integrated Management of the Pink Mealybug, *Maconellicoccus hirsutus* (Green) (Hemiptera : Pseudococcidae) Causing 'Tukra' in Mulberry

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In India, mulberry (*Morus* spp.), the sole food plant of the silkworm, *Bombyx mori* (Linn.), is prone to infestation by the pink mealybug, *Maconellicoccus hirsutus* (Green). Infestation by this pest causes apical shoot malformation, popularly known as 'tukra'. Occurrence of tukra causes an appreciable reduction in leaf yield and quality, leading to low silkworm cocoon productivity. For management of *M. hirsutus* (Tukra), an IPM package comprising mechanical, chemical and biological measures was demonstrated in the mulberry gardens of five Government Silk Farms in Mysore District (Karnataka, India) during 1995-96. A suppression of 76.0% in tukra incidence and 90.19% in mealybug population was recorded by employ the IPM package which led to an estimated 4,000 kg recovery in leaf yield/ha/year. The impact of IPM package in the management of *M. hirsutus*, the role of biocontrol agent (*Cryptolaemus montrouzieri* Muls.) in pest suppression and the cost-benefit analysis of the IPM package are discussed.

Key words : IPM, Mealybug, Tukra, *Cryptolaemus montrouzieri*

Introduction

The pink mealybug, *Maconellicoccus hirsutus* (Green) occurs in more than 13 tropical and subtropical countries of the world. The pest is reported to infest altogether 125 agricultural and horticultural crops which include 30 host plants from India (Mani, 1989). The important host plants reported from India include cotton, croton, brinjal, lady's finger, grapevine, *Hibiscus*, *Phyllanthus*, mulberry, etc. Although the first report of *M. hirsutus* in association with mulberry dates back to 1908 (Mishra, 1920), serious qualitative and quantitative loss has been observed in recent years, especially in Karnataka, Andhra Pradesh and Tamil Nadu which account for more than 80% of raw silk production in India (Kumar *et al.*, 1994). As observed in other crops, the infestation of mulberry by mealybug causes apical shoot malformation, popularly known as 'tukra'. The typical symptoms of tukra are wrinkling of apical leaves, thickening and/or flattening of apical stem and reduction in internodal distance. In cases of heavy infestation, the leaves on the apical shoot turn yellow and are shed prematurely. Finally, the tukra-affected plants acquire stunted growth, leading to reduction in leaf yield. Additionally, due to heavy feeding by the pest, the leaves on the apical part become inferior in quality.

The average incidence of tukra in the southern states of India is recorded to be 34.24% (Manjunath *et al.*, 1996), and the reduction in leaf yield is estimated to be 4500 kg/ha/yr (Kumar *et al.*, 1994). As a result, sericulturists are forced to forego a rearing capacity of about 450 layings (a laying is the total number of eggs laid by a single silkmoth which is on average 400), thus reducing the cocoon production by about 152 kg/ha/yr. Several control measures are available against *M. hirsutus* in various crop systems in India (Mani, 1989). Owing to limited efficacy/scope of these control measures in the mulberry crop system, an IPM package developed at the Central Sericultural Research and Training Institute (CSRTI), Mysore, was tested under field conditions to minimise the loss in leaf yield due to *M. hirsutus*.

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Materials and Methods

Area of IPM test

The demonstration of the IPM package was undertaken from June, 1995 to May 1996, in five isolated Government Silk Farms in the Mysore district (Karnataka, India), covering 2.25 ha mulberry gardens. Data on the incidence of tukra and population densities of mealybug were collected from all the five Silk Farms before implementing the IPM package. At each of the Silk Farms, an isolated control plot (0.4 ha) was maintained to record the natural fluctuations in mealybug populations and incidence of tukra.

Components of IPM

Chemical

At the beginning of implementing the IPM package, a solution of 0.2% DDVP (Nuvan-Trade name) in 0.5% soap solution was sprayed on mulberry stumps immediately after pruning of the gardens (plants) during June, 1995. Another application of pesticide was given 10 d after the first spray. Previously, it had been determined that 0.2% DDVP had a waiting period of 15 d and was safe for use with the recommended biocontrol agent (*Cryptolaemus montrouzieri*) .

Mechanical

The tukra-affected apical parts of the mulberry plants were clipped, collected in polythene bags and burnt as the mealybug colonises mainly on these parts. The method was adopted once on 35th-40th day after pruning in second (September-October), fourth (January-February) and fifth (March-April) crops. Clipping of the tukra affected parts was not carried out in the first (July-August) and third (November-December) crops when release of the biocontrol agent was undertaken.

Biological

Based on previously conducted glasshouse studies (Anonymous, 1993), release of the coccinellid predator, *Cryptolaemus montrouzieri* Muls. at 625 adults/ha, was undertaken in the mulberry gardens in two equal instalments, during August,1995 and November,1995 when the biocontrol agent performs effectively against mealybug (T. M. Manjunath, personal communication). The beetles were obtained from the insectary of CSRTI, Mysore.

Methods of collection of data

Incidence of tukra

Data on the incidence of tukra before and after employing the IPM package were collected from the treatment as well as control plots by observing 100 randomly selected plants in each sub-plot (0.1 ha) in treatment and control plots, and per cent incidence of tukra was determined according to the method of Babu *et al.* (1994).

Population density of mealybug

The population densities of different stages of mealybug i.e., egg (egg mass), nymph and adult, were recorded by counting these stages from 10 randomly selected tukra infested plants in each of the sub-plots of treatment plots before employing the mechanical and biological measures. The population densities of mealybug were recorded on the 35th-40th days after release of the biocontrol agent to determine the latter's predatory potential. An isolated control plot (0.4 ha) was maintained to record the populations of mealybug corresponding to the periods of recording the populations in the treatment plots.

Assessment of leaf yield

The leaf yield data from the treatment and control plots in the Silk Farms were recorded in each crop when the leaf was harvested for silkworm rearing.

Statistical tests

Data obtained from the experiments were subjected to paired t test for comparing the means of individual samples collected from different Silk Farm at different interval of time.

Results and Discussion

The results on the incidence of tukra are presented in Table 1. Before employing the IPM package, the tukra incidence in different Silk Farms varied from 36.18 to 92.08%. It is clear from the analysis of data that following the adoption of IPM, the incidence of tukra declined significantly ($P < 0.01$) in all the Silk Farms and the values ranged from 7.45 to 20.28%, thus showing a suppression of 76.0% in tukra incidence. As a result, there was about 4,000 kg recovery in the leaf yield per ha/yr. The incidence of tukra in control plots corresponding to the period after adoption of IPM varied from 25.72 to 80.58%. Therefore, the actual impact of was 72.85%, leading to an estimated recovery of about 3,800 kg in leaf yield/ha/yr.

Data on the average populations of mealybug before and after release of the predatory beetle, *C. montrouzieri*, are given in Table 2. The mealybug populations (egg masses, nymphs and adults together) per plant varied from 20.32 to 36.0 before release and from 1.52 to 4.33 mealybugs per plant on the 35th day after release of the beetle in different Silk Farms. The corresponding values for the control plots (located 1/2 Km away) ranged 21.75-48.17 and 10.66-35.71, respectively. Examination of the data reveals that release of the beetle led to an average reduction of

Table 1. Reduction in tukra incidence and recovery in leaf yield following IPM against *Maconellicoccus hirsutus*

Sl. no.	Name of the Silk Farm/RSRS	% tukra incidence: Before adoption of IPM	% tukra incidence: After adoption of IPM	% tukra incidence: Control (b) (Mean±SE)	t value	% reduction in tukra incidence following IPM	Recovery in leaf yield/ crop/acre (Kg)	Estimated recovery in leaf yield/ha/yr (Kg) (Mean±SE)
1.	Govt.Silk Farm Kuderu (DOS)	81.83	19.25±0.85	70.95±0.77	58.00*	76.47	380.0±21.75	4750.00±243.88
2.	Govt. Silk Farm, Chamrajnagar	36.18	14.30±0.33	25.75±1.82	7.65*	60.47	306.37±16.63	3829.62±186.42
3.	Govt. Silk Farm, Horlahalli	43.62	7.45±0.34	35.24±1.45	13.46*	82.92	273.17±27.66	3414.68±310.16
4.	TSC, Mugur (CSB)	92.08	15.83±1.75	80.58±1.61	39.86*	82.80	324.77±12.32	4059.68±138.17
5.	RSRS, Chamrajanagar	89.64	20.28±1.27	71.56±1.11	23.62*	77.38	300.30±50.22	37.53.75±562.13

(a) Avg. of 5 crops from each Silk Farm
(b) Tukra incidence in control plots corresponding to the period after adoption of IPM
* significance at 5%

Table 2. Reduction in mealybug populations following the release of *Cryptolaemus montrouzieri* (a) at diffrent Silk Farms

Sl. no.	Name of the Silk Farm/RSRS	Area (ha)	Treatment: Mealybug population/ plant before release of *C. montrouzieri* (Mean±SE)	Treatment: Mealybug population/ plant 35 d after release of *C. montrouzieri* (Mean±SE))	t value	% suppression in mealybug population	Control (b): Initial popn. of mealybug /plant (Mean±SE)	Control (b): Mealybug population/ plant after 35 days (Mean±SE)	t value	% suppression in mealybug population
1.	Govt.Silk Farm Kuderu (DOS)	1.0	36.00±2.84	2.24±0.50	11.59*	93.78	48.17±3.21	15.12±0.92	12.79*	68.81
2.	Govt. Silk Farm, Chamrajnagar	1.0	22.71±2.17	2.58±1.26	33.24*	88.63	26.50±2.60	23.80±1.57	0.92 NS	10.18
3.	Govt. Silk Farm, Horlahalli	1.0	20.32±2.54	1.52±0.31	4.38*	92.51	21.75±1.43	10.66±1.09	6.35*	50.98
4.	TSC, Mugur (CSB)	1.0	28.6±1.73	4.33±0.21	33.60*	84.86	36.50±0.99	28.00±1.02	8.04*	23.28
5.	RSRS, Chamrajanagar	1.0	30.38±1.93	2.68±0.42	13.03*	91.17	44.00±1.89	35.71±0.40	4.21 NS	18.84

(a) Adults of *C. montrouzieri* were released at 625/ha
(b) Population of mealybug in control plots corresponding to the periods of treatment.
* Significance at 5%, NS (Non significance)

90.19% in mealybug populations against 35.98% in mealybug populations in control plots. Thus the actual suppression in mealybug population recorded due to release of predatory beetle in treatment plots was 54.21%.

Several methods, namely mechanical (pruning and destruction of mealybug infested plants and banding the stem/shoot with sticky substances) (Bedford,1935; Ranga Raddy and Lakshmi Narayana, 1986), chemical (Dutt, 1959; RangaReddy and Lakshmi Narayana, 1986), botanical (plant extracts) (Babu *et al.*, 1994; Verghese, 1997) and biological (Compere, 1938; Ferriere, 1951, Kamal, 1951; Babu, 1986; Manjunath, 1985; Rangareddy and Lakshmi Narayana, 1986; Mani, 1987) have been employed for management of *M. hirsutus* in various horticultural and agricultural crops. Preliminary studies conducted by Kumar *et al.* (1994) led to 48.02, 56.10 and 41.0% suppression in tukra incidence following the adoption of mechanical (clipping and burning tukra affected parts), chemical (spraying 0.2% DDVP in 0.5% soap solution) and biological (releasing the coccinellid predator, *C. montrouzieri* at 625 adults/ha) methods, respectively. Further, Kumar *et al.* (1994) have recorded 72% reduction in tukra incidence by employing an integrated pest management package comprising these control measures. In the present study, where a similar IPM package has been employed, a similar degree of suppression ranging from 76.47 to 82.81% in tukra incidence was recorded at field level.

With regard to suppression of mealybug populations following the release of *C. montrouzieri,* no field studies have been conducted so far in the mulberry crop system. Laboratory studies on the predatory potential of *C. montrouzieri* indicated that a single grub consumes 900 eggs, 260 nymphs, or 30 adults of *M. hirsutus* (Anonymous,1990). Further, in glasshouse studies (Anonymous, 1993), it was found that the population of *M. hirsutus* was reduced to less than one per plant from an initial population of 50 per plant, 40 days after release of *C. montrouzieri* at 1 beetle per infested plant. In the present study, a highly significant suppression in mealybug population was recorded in all the Silk Farms following the release of *C. montrouzieri* at 625 adults/ha, thus proving the efficacy of *C. montrouzieri* under field conditions. Furthermore, the predator was found to have persist in the released plot as there was a considerable population of grubs when observations were made on the 35th day following the release of *C. montrouzieri*. The presence of a few first instar grubs also was observed in the control plots, thereby indicating the high dispersal ability of the predator. Obviously, the presence of grubs and other factors, if any, have contributed to a considerable suppression (35.98%) in the mealy bug population in control plots 35 days after the release of the predator in the treatment plots. According to Mani and Thontadarya (1988), release of *C. montrouzieri* at 1500 adults per 0.4 ha gave effective suppression of *M. hirsutus* infesting grapevine within 75 days.

The adoption of the IPM package tested here costs about Rs.950.0/ha/yr which results in the recovery of 4,000 Kg leaf yield. This provides an additional income of Rs.8000.0 (@ Rs.2/- per Kg of leaf), thus fetching a net profit of Rs.7050.0. The cost benefit ratio of the IPM package works out is 1:8.4.

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