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Efficacy of Integrated Barrier System for Management of Pink Mealybug *Maconellicoccus hirsutus* (Green) in Mulberry

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ABSTRACT: Efficacy of bio-pesticide Spinosad 45% SC in combination with barrier system was studied to control the pink mealybug *Maconellicoccus hirsutus* (Green) infested mulberry (*Morus alba* L.) variety S-1635. The results revealed that the Percent Infestation (PI) was more in summer and winter seasons *i.e.*, 67.28% & 67.13%, respectively. Likewise, the Percent Damage Index (PDI) exhibited 37.99% in summer followed by winter 31.11%. It was also observed that for the both PI&PDI during rainy season, which were found to be less *i.*e., 53.65% and 21.11%, respectively. The mean performance of pest reduction % over the seasons revealed that the barrier T3 (Neem cake + Spinosad) showed 85.60 % pest reduction followed by the barrier T2 (Husk ash + Spinosad) (72.70 %) compare to control (Spinosad only) (47.73 %) on infested plants. The gain % of pest reduction obtained for barrier alone was recorded 44.24%, 36.65%, 34.35% and 30.05% for T3, T4, T2 and T1, respectively when compared to control. The results also revealed that almost all the Treatment has showed positive correlation with temperature and relative humidity but the rainfall showed negative correlation effect. The both Autumn and Spring crops of silkworm (*Bombyx mori* L.) hybrids rearing results revealed that there was no any significant ill effect on silkworm rearing on larval growth, cocoon yield and cocoon quality parameters when fed with Spinosad treated leaves after 30 days, which confirmed the safety period of bio-pesticide. Hence such a 2-dimensional IPM approach would give more effective results than the bio-pesticide alone was discussed.

Keywords: Pink mealybug, Bio-pesticide, Eco-friendly, Barrier, IPM.

INTRODUCTION

The pink mealybug, *Maconellicoccus hirsutus* (Green) (*Hemiptera: Pseudococcidae*) is a major polyphagous pest, which infests more than 300 host plants (Ghose, 1972; Tewari *et al*., 1994; Reddy *et al*., 2009). The pink mealy bug causes nearly 15% crop losses in mulberry (*Morus alba* L.) resulting unsuitable for silkworm feeding (Manjunath *et al*., 2003). Mealy bug inject some toxic saliva into the mulberry plant while infesting & accordingly, mulberry defence mechanism exhibits stunted growth with curling leave known as 'TUKRA' (Misra, 1919). In India, the occurrence of this pest on mulberry was reported in Murshidabad District of West Bengal (Mukherjee, 1899). Further, Sathyaprasad *et al*., (2000) has reported that the mealy bug incidence caused an estimated leaf yield loss of 4500 kg/ha/year amounting to 34.24% (Manjunath *et al*., 2003) resulting less brushing 450 dfls/ha/year, which leading to decline in cocoon production by 150 kg/ha/year (10-15%) and it is an avoidable leaf loss (Lalitha *et al*., 2015) through managing mealy bugs infestation by both abiotic (irrigation and wind) and biotic means (ants, human and birds; Lavanya *et al*., 2004).

Moreover, the management of pink mealy bug has been a problem due to its protective cover made by wax, hiding habitat under curled leaves, cracks, roots soil etc. and its rapid multiplication rate both by sexually and asexually (Parthenogenesis). That is why it is popularly known as "HARD TO KILL PEST". The problem of TUKRA has becomes rampant in all sericultural belts of Tamil Nadu and other parts of India (Datta, 1993). In spite of adoption of several IPM packages of practices, the mealy bugs are still causing crop loss contributing to the shortfall of silk productivity (Katiyar *et al*., 2001). Hence, it is imperative to find out a right strategy to combat against mealy bug without adverse effect on environment (Dhaliwal and Ramesh 1996).
With this backdrop, in the present study as a part of IPM approach a bio-pesticide *viz*., Spinosad 45 % SC (which is new to mulberry) and some barrier stuffs were evaluated as a 2-dimensional approach to control the pink mealy bug in the mulberry eco system.

MATERIALS AND METHODS

Various barrier combinations were evaluated for the management of pink mealy bug in mulberry variety, S-1635 under the experimental layout of randomised block design (RBD; 3mt × 4mt size plots; 3' × 3' plant spacing, 20 plants/plot; four replications/ treatment) at

RSRS-Jorhat, Assam (Lat:26.712; Long:94.187 N26°42′45.90461′E 94°11′13.88569′) during April 2019 to December 2020. The barrier treatments are mentioned below:

T1: lime powder + Spinosad 45% SC
T2: Paddy husk ash + Spinosad 45% SC
T3: Neem cake + Spinosad 45% SC
T4: Sawdust + Spinosad 45% SC
T5: No barrier + Spinosad 45% SC

Mealy bug population density (nymphs & adults) was recorded at weekly intervals (5 plants; 10 leaves per treatment). The parameters studied was Percentage of Infestation (PI); Percent Damage Index (PDI) and Pest Reduction percentage (R%).

Percentage of Infestation (PI) =

$$\frac{\text{Number of Shoots Infested in the Plant}}{\text{Total Number of Shoots in the Plant}} \times 100$$

Percent Damage Index (PDI) =

$$\frac{\text{Sum of Numeric Grades}}{\text{Total Number of Plants} \times \text{Maximum Grade}} \times 100$$

Pest Reduction (R%) =

$$\frac{\text{Number of Bug Before Spray} - \text{Number of Bug after Spray}}{\text{Number of Nymphs Before Spray}} \times 100$$

The data recorded was analysed by employing Factorial ANOVA to capture the treatment, effect across seasons. Karlpearson's correlation analysis was also performed to know the degree relationship between % pest reduction and meteorological parameters (maximum & minimum temperature, maximum & minimum relative humidity and rainfall) during the experimental study. To determine the safety period of pesticide, two silkworm rearing were conducted during Autumn and Spring seasons with SK & KDH hybrids silkworm. Accordingly, 'student t' test was employed on each silkworm economic characteristics to study the comparative performance.

RESULTS

Efficacy of bio-pesticide Spinosad 45% SC combined with the barrier stuffs on Pink Mealybug (*M. hirsutus* G.) population was evaluated. The results revealed that the Percent Infestation (PI) was more in summer and winter months (67%). Likewise, the Percent Damage Index (PDI) exhibited 38% in summer followed by 31% in winter. It was also observed that for the both PI (54%) & PDI (21%) during rainy season which were found to be less. The mean performance of pest reduction % over the seasons revealed that during summer, the barrier T3 showed 86% pest reduction followed by T2 (73%) as compared to control (48%). Similarly, during winter season, the T3 combination has shown 89% pest reduction followed by T4 (78%) and T2 (77%) with same kind of effect. During winter season the barrier alone contribute 35% pest reduction when compared to control. Similarly, the trend observed during Rainy season revealed that the T3 barrier has shown 84% pest reduction followed by T4(76%), T2(65%) and T1(63%) as compared to control (52%).

Table 1: Performance of barrier system on pink mealybug across seasons in Mulberry.

Treatments & Seasons	% Incidence	PIOC	% Damage Index	PDOC	% Reduction	PROC
T1	58.93	-6%	33.91	13%	68.24	43%
T2	61.78	-1%	35.61	18%	72.70	52%
T3	59.69	-5%	36.80	22%	85.60	79%
T4	56.61	-10%	31.04	3%	75.35	58%
T5 (Ctrl)	62.69		30.07		47.73	
SEm±	0.566		0.348		0.407	
CD@5%	1.649		1.013		1.184	
Summer (S)	62.73	0%	45.10	50%	66.20	39%
Rainy (R)	53.96	-14%	23.43	-22%	68.22	43%
Winter (W)	63.13	1%	31.92	6%	75.35	58%
SEm±	0.731		0.449		0.525	
CD@5%	2.129		1.307		1.529	
S × T1	61.48	-2%	42.38	41%	66.39	39%
S × T2	67.48	8%	50.14	67%	75.08	57%
S × T3	57.77	-8%	52.66	75%	83.82	76%
S × T4	59.67	-5%	42.36	41%	72.51	52%
S × T5	67.28	7%	37.99	26%	33.20	-30%
R × T1	53.39	-15%	26.78	-11%	63.20	32%
R × T2	56.75	-9%	24.85	-17%	65.46	37%
R × T3	56.78	-9%	24.04	-20%	84.26	77%
R × T4	49.21	-22%	20.39	-32%	75.78	59%
R × T5	53.65	-14%	21.11	-30%	52.42	10%
W × T1	61.92	-1%	32.58	8%	75.14	57%
W × T2	61.11	-3%	31.85	6%	77.55	62%
W × T3	64.53	3%	33.69	12%	88.72	86%
W × T4	60.95	-3%	30.36	1%	77.77	63%
W × T5	67.13	7%	31.11	3%	57.56	21%
SEm±	1.266		0.778		0.909	
CD@5%	3.687		2.265		2.647	

PICO: Percent incidencet over control; PDOC: Percent damage over control; PROC: Percent reduction over control

Further, the pest reduction was correlated with environmental factors (temperature, relative humidity and rain fall). The results revealed that almost all the treatments have showed positive correlation with temperature (Table 2 & Fig. 1), whereas, mealy bug with relative humidity and rain fall were shown as negative correlation across the treatments (Fig. 2 & 3).

Table 2: Month-wise Meteorological Parameters in the study.

Month	Temperature			Relative Humidity (RH)			Rainfall (mm)	Days
	Max	Min	Avg.	Max	Min	Avg.		
April	28.2	17.0	23.4	87.0	52.0	79.9	238.0	7
May	31.0	21.0	28.0	96.0	52.0	80.2	295.2	18
June	32.0	22.0	29.7	94.0	66.0	85.8	347.0	17
July	32.4	20.0	29.6	94.0	62.0	88.4	622.0	26
August	37.2	23.3	32.9	99.0	64.0	89.9	316.0	15
September	36.1	20.5	31.0	97.0	69.0	87.7	314.0	18
October	36.1	21.7	32.0	97.0	71.0	89.7	188.0	10
November	29.0	18.0	26.9	92.0	40.0	70.3	34.5	3
December	28.0	16.0	24.9	84.0	36.0	61.2	3.5	1

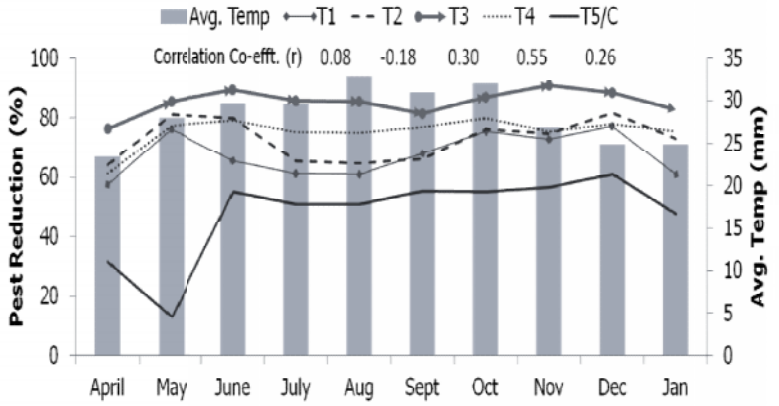

Fig. 1. Correlation co-efficient between mealybug reduction & temperature across barrier system in mulberry ecosystem.

Bio-assay study was conducted during Autumn and Spring season with three popular silkworm hybrids (SK6.7, BCon1.4 and KDH1). This assay in terms of fed the mulberry leaves to silkworms i.e., 30 days old treated and normal leaves (control) to determine the safety period of pesticide used in the experiment. The results revealed that there was no significant effect on silkworm cocoon characteristics (Table 3).

Table 3: Bio-assay performances with popular silkworm hybrids between treated (30 days duration) & untreated pesticide sprayed mulberry leaves.

Parameters	Treatment	Control	P-value (t-stat)
Fecundity (No)	529	531	0.932
Hatching (%)	97.60	96.10	0.085
10 matured Larval Wt. (g)	31.53	31.9	0.703
ERR by 10k larvae (No)	6800	6766	0.906
Cocoon Yield/ 100 dfls (kg)	45.01	44.78	0.902
Cocoon Wt. (g)	1.401	1.403	0.766
Shell Wt. (g)	0.251	0.25	0.633
Shell (%)	17.90	17.80	0.496
Note: P<0.05 signals the significant at 5%			

DISCUSSION

The study on population dynamic of Pink mealy bug and its infestation rate observed across different seasons on mulberry in Assam, but highest during summer and winter season because of environmental factors especially during these seasons are more congenial for mealybug infestation in the mulberry ecosystem (Ghose, 1972; Thinnaluri *et al*., 2014; Chanda *et al*, 2018).

The barrier stuffs selected for the study was found as triggered mechanism for further strengthening the aerial application of bio-pesticide Spinosad. The use of plant derivatives is gaining attention due to process

specificity, bio-degradability, low residual toxicity in the eco-system (Fowcett and Spenser, 1970). Use of recommended botanicals in IPM for the management of pink mealybug does not have negative impact on natural enemies and environment (Mukhopadhyay *et al*., 2011). Mealybug infestation is prevalent mainly during summer and pre-monsoon season (Ghose, 1972). The bio-pesticide Spinosad 45% SC is an insecticide based on chemical compounds found in the bacterial species *Saccharopolyspora spinosa*. The genus *Saccharopolyspora* was discovered in 1985 in isolates from crushed sugarcane. This genus is defined as aerobic, Gram-positive, non-acid-fast actinomycetes with fragmenting substrate mycelium. Spinosad contains a mix of two spinosoids, spinosyn A, the major component, and spinosyn D (the minor component), in a roughly 17:3 ratio.

The main objective of the study to control the infestation rate of pest through application of barrier stuffs combined with spraying of bio-pesticide Spinosad 45% SC. The above results clearly showed that among the barrier stuffs evaluated for the study, the T3 barrier neem cake has shown most effective barrier material than the other stuffs used, which has shown a good interaction effect with Spinosad combination to reduce more than 80% pest population within 15 days' time interval. Further, there was a significant variation on interaction of treatments over the seasons as like genotypes interact well with environment, the findings are corroborated with earlier report of Mani and Thontadarya (1988). But in case of rainy season affects the application of barrier stuffs and bio-pesticide as it washes by rain (James & Fofanah, 1992; Koli, 2003), however, nature itself manages pest population at optimum level. It was observed that the selected spot of the study received 1252 mm rainfall in 59 days out of 92 days of rainy season and the overall rainfall was recorded 2358 mm during study period (Table 2). Hence, the evaluated IPM package for the present study has shown its fullest effect during hot weather condition than in high humidity condition.

The newly employed bio-pesticide Spinosad 45% SC was not so far used in IPM approach of mulberry pest control; hence it is mandatory to study its effect on silkworm feeding to determine its safety period of concentration at LC50 selected *ie*., 16 ml/L. The bio-assay study with silkworm hybrids (fed the 30 day old sprayed leaves) were shown no ill effect on silkworm rearing. Hence, this 2-dimensional IPM approach (neem cake application + spinosad spray) would be a right choice for management of pink mealy bug in mulberry ecosystem during summer & winter months.

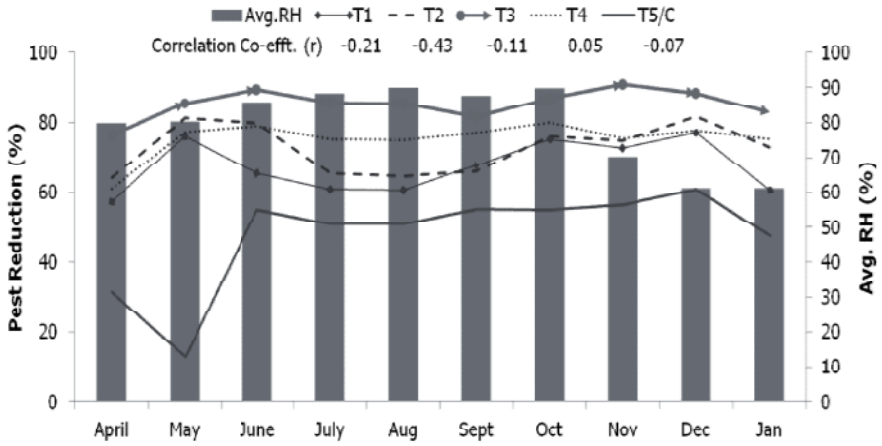

Fig. 2. Correlation co-efficient between mealybug reduction & relative humidity across barrier system in mulberry ecosystem.

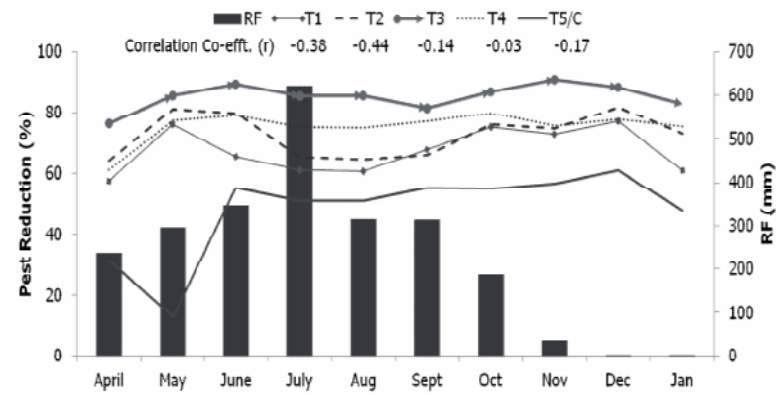

Fig. 3. Correlation co-efficient between mealybug reduction & temperature across barrier system in mulberry ecosystem.

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