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EVALUATION OF IPM MODULES AGAINST *DIAPHANIA CAESALIS* (WALKER) IN JACK FRUIT

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ABSTRACT

Field trials were conducted to evaluate four IPM modules against jack shoot and fruit borer *Diaphania caesalis* (Walker). Among different canopy types, the spreading type canopy was the most susceptible. The fruit damage on covered and hooked fruits were significantly lesser compared to control. Among the five modules evaluated- Module I (*Nomuraea rileyi* (WP)@ 10g/ l, pongamia soap 5 gm/ l, *Trichogramma chilonis*@ 45,000 adults and *Apanteles stantoni*@ 450 adults/ acre) were more effective. The laboratory mass multiplied parasitoids and pathogens provided an effective control. Moreover, ecofriendly botanical insecticides i.e. neem and pongamia are equally effective.

Key words: Jack fruit, *Diaphania caesalis*, ecology, biocontrol, life history, chemical control, neem, pongamia, *Nomuraea rileyi*, *Trichogramma chilonis*, *Apanteles stantoni*, hooking, blagging

Jack fruit is the largest tree-borne tropical fruit species found in high rainfall, coastal and humid areas of the world (Sturrock, 1959). In India, about 39 species of insects are known to attack jack fruit (Butani, 1979). Among them, the shoot and fruit borer *Diaphania caesalis* (Walker) is a major (Soumya et al., 2015; Soumya et al., 2019). Though ample studies have been conducted on its biology (Manjunatha et al., 2014; Soumya et al., 2019), the literature available on its management through IPM is scanty. Although pesticides generally are used to kill a particular target pest, several other non-target pests and beneficial organisms also will be killed in the process (Patil and Bheemanna, 2015). In tree crops, especially with a large canopy, like jack fruit tree application of insecticides is more difficult, and aerial sprays are found effective (Hill, 2008). However, the application of pesticides by aerial spray method can cause adverse effects on different crops, livestock, waterways and environment. Hence, IPM is a more ecofriendly approach, especially in jack fruit, where insecticide sprays on huge canopy will be a difficult task. Although IPM represents a key strategy for the control of jack fruit pests, it has not been attempted. Therefore, this study to evaluate IPM modules against *D. caesalis.*

MATERIALS AND METHODS

Experiments were conducted in the laboratory and in the jack fruit orchards of the Indian Council of Agricultural Research- Indian Institute of Horticultural Research (ICAR- IIHR), Bengaluru (12 8'N; 77 35'E) during May 2014- December 2016. Trees selected for the study were of medium height (2.00 - 2.50 m), aged between 12 and 20 years and being pruned once in a year. Recommended agronomic practices (i.e. weeding, pruning, fertilization with minerals and organic nutrients) were followed, except pesticides. Laboratory assay was conducted with the treatments viz, neem soap (5 gm/ l), pongamia soap (5 gm/ l), *N. riley* WP (1.0x 10^9conidia/ ml @ 10 gm/ l), *B. bassiana* WP (1.0x 10^9 conidia/ ml @ 10 gm/ l), and *M. anisopliae* oil formulation (1.0 ×10^9conidia/ml @ 0.5 ml/ l). Fresh shoots with 2 - 3 leaves were kept individually in small transparent plastic trays (12x 12x 2 cm) and were sprayed with fungal pathogens and botanicals using a hand sprayer. Different larval instars of *D. caesalis* were allowed to feed on treated leaves. Five replications were maintained for each treatment. Each replication consisted of 10 larvae of first, second, third, fourth and fifth larval instars. The efficacy of treatments against larval instars was evaluated in the laboratory. The mortality of larval instars was observed daily up to seven days after treatments.

Field trials were conducted in a randomized complete block design (RCBD) with different treatments in ten replications, each consisting of one tree. All treatments were imposed simultaneously once a week. Foliar sprays (5 l/ tree) of botanicals i.e. neem soap and *Pongamia* soap, microbial agents i.e. *N. rileyi*, *B. bassiana* and *M. anisopliae* and organic insecticides i.e. Dipel (*Bacillus thuringiensis*) and One Up (spinosad) were applied to the crop in the morning (9.00- 10.00 hr) using knapsack sprayer (Lotus knapsack sprayer, 16l). The effect of canopy shape on *D. caesalis* infestation was evaluated. The jack fruit trees were grouped into four categories as open type (T1), oval type (T2), round type (T3) and spreading type (T4) based on their canopy shape. Fruit bagging and hooking experiments were conducted to evaluate their effect on *D. caesalis* infestation. Fruits were bagged using polyethene bags (55x 85cm) after fruit set. Tiny holes were made at the bottom of the polyethene bag for aeration and escape of transpiration water/ rainwater. Hooking was done using a small sharp forceps (10x 12x 2 cm). Wax was applied on the hooked portion to prevent water from entering into the damaged fruit, which causes fruit rotting. Data on fruit infestation and fruit weight was recorded both from bagging and hooking experiments.

Light traps (white light) were installed within the field on a pole (9 m) and were secured firmly on the ground. In order to rear *T. chilonis* and *A. stantoni* in the laboratory, rice moth, *C. cephalonica* was cultured following the methods of Kumar and Murthy (2000) and Nathan et al. (2006). Rearing of *A. stantoni* was carried out from the field-collected parasitoid cocoons as well as from parasitised *D. caesalis* larvae. The mated females of *A. stantoni* were released in the field during evening hours @ 450 adults/acre/week as followed by Mitchell et al.(1997) for *Cotesia* (=*Apanteles*) *plutellae.* Different IPM modules evaluated- Module I (*Nomuraea rileyi* (WP)@10 gm/ l, pongamia soap 5 gm/ l, *T. chilonis*@ 45,000 adults/ ha and *Apanteles stantoni*@ 450 adults/ ha); Module II (*Beauveria bassiana* @10 gm/ l, neem soap 5 gm/ l and *Apanteles stantoni* @450 adults/ ha); Module III (*Beauveria bassiana* @10 gm/ l, *T. chilonis* @ 45,000 adults/ ha and *Apanteles stantoni* @450 adults/ ha); Module IV (*Nomuraea rileyi* WP @10 gm/ l, *Apanteles stantoni* @ 450 adults/ ha) and Module V (*T. chilonis* @ 45,000 adults/ ha and *Apanteles stantoni* @ 450 adults/ ha). Observations were recorded for assessing the suppression level of *D. caesalis* and population of natural enemies. From each selected plant, 30 buds were selected randomly from the upper, middle and lower canopies to record the pest population. Infestation level was recorded before and after treatments. Incidences of pests and natural enemies were assessed one day before treatment as a pretreatment observation and on the 7th day after treatment as post-treatment observation. The data on *D. caesalis* damage in different canopy-types jack fruit trees, mean mortality of *D. caesalis* in the laboratory and in the field was subjected to one-way ANOVA followed by Tukey's Honest Significant Difference (HSD) multiple range test (p=0.05) to find the significant difference. Student 't'- test was used to compare the % fruit damaged by *D. caesalis* in hooking and bagging experiments.

RESULTS AND DISCUSSION

The extent of *D. caessalis* infestation among different canopy types of jackfruit trees was significantly different (F = 304.49.8, df = 3, 36; $P < 0.05$). In open and oval type of canopies, the number of damaged buds significantly less and ranged between 0.00-0.45 and 0.45 - 1.10 damaged buds/tree respectively. The pest incidence was relatively higher (6.42 - 11.00 damaged buds/tree) in trees with round canopy when compared to open and oval types. The spreading type canopy was most susceptible to the attack of the pest, which showed 10.87 - 14.40 damaged buds and significantly higher when compared to the other three canopy types. The results regarding the influence of canopy on *D. caesalis* infestation was similar to that of Singh and Verma (2013) who reported the greater outbreak of mango leaf webber *Orthaga euadrusalis* Hampson (Pyralidae: Lepidoptera) in mango orchards with a dense canopy. Greater infestation of *D. caesalis* in spreading type canopy could be due to the availability of more fresh shoots in these trees. The percentage of *D. caesalis* infestation in treated and control fruits was significantly different in both bagging ($t (38) = 24.63$; $p < 0.05$) and hooking ($t (38) = 16.74$; $p < 0.05$) experiments. The fruit damage in covered fruits was 0.5% while it was 31.65% in control. However, average fruit weight was 6.90 kg in bagging and 7.00 kg in control, which was not significantly different. The fruit infestation in hooked fruits was 5.50% while it was 39.5% fruits in control. Colour of the covered fruits was bright greenish-yellow and appearance was better than that of control fruits. The infestation of *D. caesalis* was lesser in bagged jack fruit as reported by Abbasi et al. (2014) in bagged guava fruits which were less infested with *Bactrocera dorsalis* Hendel (Tephritidae: Diptera).

The effect of biopesticides and botanicals screened against *D. caesalis* in the laboratory is given in Table 1. The effectiveness of *N. rileyi*, *B. bassiana,* neem soap and *Pongamia* soap on larvae was more in all larval

Table 1. Efficacy biopesticides against larval instars of *D. caesalis*

Treatments	Mortality (%)					
	1st instar	2nd instar	3rd instar	4th instar	5th instar	Average
N. rileyi	99.00	89.29	86.85	65.71	59.29	80.03
	(9.95) a	(9.45) a	(9.32) a	(8.11) a	(7.70)b	(8.95)a
B. bassiana	95.71	85.57	87.14	65.14	64.29	79.57
	(9.78) a	(9.25) a	(9.34) a	(8.07) a	(8.02) a	(8.92)a
M. anisopliae	40.86	32.00	24.29	20.00	18.57	27.14
	(6.39)b	(5.66) b	(4.93) b	(4.47) b	(4.31) c	(5.21)b
Neem Soap	74.29	70.00	71.43	70.00	68.33	70.81
	(8.62) a	(8.37) a	(8.45) a	(8.37) a	(8.27) a	(8.41)a
Pongamia Soap	91.43	85.71	85.71	86.67	87.14	87.33
	(9.56) a	(9.26) a	(9.26) a	(9.31) a	(9.34) a	(9.35)a
Control	2.50	1.00	0.00	0.00	0.00	0.70
	(1.58)c	(1.00) c	(0.00) c	(0.00) c	(0.00) d	(0.82) c

Values in parentheses square root-transformed. Means in columns followed by different alphabets significantly different (Tukey's HSD test, p < 0.05, ANOVA).

Table 2. Effect of IPM modules on bud/ fruit damage by *D. caesalis* and on natural enemies in jackfruit orchard

Module	Daamge on beds	Damage on fruits	Reduviids (No/ plant)		Spiders (No/ plant)		Coccinellids (No/ plant)		*A. stantoni* (% parasitism)	
			BT	AT	BT	AT	BT	AT	BT	AT
Module-I	3.43a	5.50 a	0.17a	0.18a	0.88a	0.90a	1.54a	1.45a	36.00 b	93.50a
Module-II	11.50 b	10.00 b	0.16a	0.14a	0.80a	0.78a	1.60a	1.80a	31.46b	87.90a
Module-III	10.10 b	10.59 b	0.18a	0.18a	0.90a	0.88a	1.49a	1.50a	33.25b	88.50a
Module-IV	16.75 b	11.50 b	0.45a	0.4a	1.15a	1.10a	2.20a	2.10a	37.10b	87.00a
Module-V	17.50 b	12.10 b	0.17a	0.13a	1.60a	1.50a	1.40a	1.90a	32.66b	85.90a
Control	97.25 c	35.40 c	0.41a	0.42a	1.10a	1.10a	1.50a	1.70a	38.15a	37.50a

Means in columns followed by different alphabets significantly different (p < 0.05,'t' test).
BT- Before treatment, AT- After treatment.

instars of *D. caesalis* except in fifth. The mortality in fifth instar larvae was highest with pongamia soap, neem soap and *B. bassiana* treatments when compared to neem soap *N. rileyi* and *M. anisopliae;* mortality of *D. caesalis* was highest in pongamia soap (87.33%) followed by *N. rileyi (*80.03%), *B. bassiana* (79.57%), neem soap (70.81%) and *M. anisopliae* (27.14%) (Table 1). The present result with *N. rileyi* is similar to Burges (1998) and Ramanujan et al. (2003) who reported greater efficacy of *N. rileyi* formulation, against lepidopteran pests. Yi and Qui (1999) reported that Bt insecticide was effective in controlling *D. indica*. The effectiveness of *T. chilonis* in controlling *D. caesalis* was similar to that reported by Jalali and Singh (1992), Singh et al. (2004). Krishnamoorthy (2012) and Sardana et al. (2005), who reported that the inundative release of *T. chilonis* reduced the incidence of several lepidopteran pests. The mortality of *D. caesalis* was more in all the five modules of IPM. The bud damage by *D. caesalis* on the seventh day after treatment was significantly lesser in M- I (3.43%) followed by M- II (10.10 %), M- III (11.50 %) and M- IV (16.75 %) and M- V (17.50 %). The fruit damage in different IPM modules remained significantly lowest in M-I (5.50%) %) followed by M-II (10.50%), M- III (10.59%), M- IV (11.50%) and M- V (12.50%) as compared to control (35.40 %) (Table 2).

The natural enemy (reduviids, spiders, coccinellids and *A. stantoni)* population did not significantly differ with IPM modules evaluated. However the parasitization by the larval parasitoid *A. stantoni* expressed as percentage differed significantly among the modules (Table 2). Dipel and *B. bassiana* has been widely used for the control of different economically important lepidopteran pests, i.e. *Helicoverpa armigera* (Hubner) (Noctuidae: Lepidoptera) and *S. litura* (Chandrakar et al., 1999; Mohammed et al., 2005). The results regarding the effect of neem in controlling *D. caesalis* was similar to that of Gowda (2000) who reported that neem seed kernel extract (NSKE) and neem oil and pungam (*Pongamia pinnata)* seed extract were effective in controlling *D. pulvernlentalis* in mulberry crop.

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