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Biorational management of the chiku moth *Nephoteryx eugraphella* (Ragonot)

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Abstract

The study on effectiveness of various bio-pesticides and biorational pesticides for controlling chiku moth (*Nephoteryx eugraphella*) was carried out in the field of Junagadh Agricultural University. Entomopathogenic fungi like *Beauveria bassiana*, *Nomuraea rileyi* and *Metarhizium anisopliae* as well as *Bacillus thuringiensis*, Neem Seed Kernel Extract 5%, Panchgavya 5%, Neemashttra 1% were applied two times at higher pest infestation. Out of these treatments treatment of Neem Seed Kernel Extract 5% were found the most effective which was followed by *Beauveria bassiana* 1.1WP (1×10^8 CFU/g) (0.0092).

Keywords: Chiku moth, NSKE bio-pesticides management, sapota

Introduction

The sapota, scientifically known as *Manilkara achras* (Miller) Fosberg (synonym: *Achras sapota* L.), is a fruit-bearing tree belonging to the family Sapotaceae and subfamily Sapotoideae. Commonly referred to as chiku, ciku, dilly, naseberry, sapodilla, plum, and chico, this fruit has its origins in Mexico and Central America. Over time, it has been cultivated widely throughout the tropical regions of the world. The Spanish are credited with introducing sapota to the Philippines, from where it later spread to Malaysia and other regions (Purseglove, 1968) [7]. In India, sapota cultivation began in 1898 in Gholkwad, a village in Maharashtra, under the initiative of Patel Kavsaji Palanji (Chandha, 1993) [2]. Today, it is commercially grown in several Indian states, including Gujarat, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Kerala, Uttar Pradesh, West Bengal, Punjab, and Haryana (Cheema *et al.*, 1954; Vevai, 1971) [2, 9]. Among the 41 varieties grown across the country, "Kalipatti" stands out as a particularly notable variety, especially prevalent in Gujarat and Maharashtra. The sapota tree plays a crucial role in the socio-economic development of both small-scale and large-scale farmers (Shukla, 2009) [8]. However, it is also susceptible to more than 25 insect pests (Wagh *et al.*, 2012) [10]. In Gujarat, some of the significant insect pests that pose a threat to sapota trees include the chiku moth or chiku leaf weber (*Nephoteryx eugraphella* Ragonot), chiku bud borer (*Anarsia achrasella* Bradley), leaf miner (*Acrocercops gemoniella* Stainton), leaf folder (*Banisia myrsusalis* lateralis Walker), fruit fly (*Bactrocera correcta* Bezzi), seed borer (*Trymalitis marginatus* Meyrick), mite (*Tukerela kumaoensis* Gupta), and mealybug (*Ferrisia virgata* Cockerell). Among these, *Nephoteryx eugraphella* Ragonot is particularly destructive, being the primary pest for sapota. This pest was initially reported on *Mimusops elengi* Linnaeus by Hampson in 1896 [5] and later on sapota by Misra in 1920 [6]. The caterpillars of this pest primarily feed on the leaves but can also attack buds, flowers, and occasionally tender fruits.

Materials and Methods

To evaluate the bio-efficacy of different bio-pesticides against chiku moth, field trials were conducted from March 2023 to February 2024 at the Jambuvadi Farm, Junagadh Agricultural University, Junagadh (Gujarat). The study included nine treatments (Table 1), each repeated three times in a Completely Randomized Design. Thirty sapota trees (Var. Kalipatti) were used, and the treatments were evaluated based on the percentage of twig infestation. For recording observations, four directions were chosen, and eight twigs per plant were randomly

selected and tagged. The percentage of infestation was recorded, and insecticidal treatments were applied using a gator sprayer when the pest population reached a high level. Pre- and post-treatment observations were recorded before and after 1 day before spray (1 DBS), 1 days after spray (3 DAS), 7 days after spray (7 DAS), and 10 days after spray (10 DAS).

Obtained data were converted into percent reduction infestation by chiku moth over control through the following

formula (Abbott, 1925) ^[1].

$$\text{Percent reduction over control} = \frac{C-T}{C} \times 100$$

Where,

T = Percent infestation of chiku moth from the treated plot

C = Percent infestation of chiku moth from the controlled plot

Table 1: Details of bio-pesticidal treatments

Sr. No.	Treatments	Conc. (%)	Dose/10 lit
1.	<i>Beauveria bassiana</i> 1.15 WP (1 × 10 ⁸ CFU/g)	0.007	60 gm
2.	<i>Beauveria bassiana</i> 1.15 WP (1 × 10 ⁸ CFU/g)	0.0092	80 gm
3.	<i>Bacillus thuringiensis</i> 5 WP (1 × 10 ⁸ CFU/g)	0.01	20 gm
4.	<i>Metarhizium anisopliae</i> 1.15 WP (1 × 10 ⁸ CFU/g)	0.007	60 gm
5.	<i>Metarhizium anisopliae</i> 1.15 WP (1 × 10 ⁸ CFU/g)	0.0092	80 gm
6.	<i>Nomuraea rileyi</i> 1.15 WP (1 × 10 ⁸ CFU/g)	0.0092	80 gm
7.	Neem Seed Kernel Extract 5%	0.015	30 ml
8.	Panchgavya 5%	0.0135	45 ml
9.	Neemashtra 1%	0.03	300 ml
10.	Untreated control	-	-

Results and Discussion

The efficacy of different bio-pesticides against chiku moth was observed separately on twig from the tree. The data

regarding the effectiveness of various treatments at different intervals are described below in detail.

First spray

Table 2: Efficacy of different Bio-pesticides against chiku moth, *N. eugraphella* infesting sapota (First spray)

Tr. No.	Treatments	Twig damage (%)				
		Before spray	Days after spraying			
			1	3	7	10
T1	<i>Beauveria bassiana</i> 1.15 WP (1 × 10 ⁸ CFU/g) (0.007)	32.65 (29.11)	26.80 (20.33)	25.85 (19.01)	24.91 (17.74)	26.31 (19.65)
T2	<i>Beauveria bassiana</i> 1.15 WP (1 × 10 ⁸ CFU/g) (0.0092)	32.43 (28.76)	23.58 (16.00)	22.41 (14.54)	21.36 (13.27)	22.24 (14.32)
T3	<i>Bacillus thuringiensis</i> 5 WP (1 × 10 ⁸ CFU/g) (0.007)	32.50 (28.86)	25.56 (18.61)	24.77 (17.55)	24.12 (16.70)	25.50 (18.53)
T4	<i>Metarhizium anisopliae</i> 1.15 WP (1 × 10 ⁸ CFU/g) (0.007)	30.22 (25.34)	28.55 (22.84)	27.82 (21.78)	28.07 (22.14)	28.15 (22.26)
T5	<i>Metarhizium anisopliae</i> 1.15 WP (1 × 10 ⁸ CFU/g) (0.0092)	29.47 (24.20)	27.18 (20.87)	25.91 (19.10)	25.08 (17.97)	26.59 (20.03)
T6	<i>Nomuraea rileyi</i> 1.15 WP (1 × 10 ⁸ CFU/g) (0.0092)	31.48 (27.27)	25.35 (18.33)	24.49 (17.18)	23.81 (16.30)	24.95 (17.79)
T7	NSKE 5% (0.015)	29.47 (24.20)	23.23 (15.56)	22.14 (14.21)	21.24 (13.12)	22.10 (14.15)
T8	Panchgavya 5% (0.0135)	28.79 (23.20)	29.37 (24.05)	28.93 (23.40)	28.61 (22.93)	28.95 (23.43)
T9	Neemashtra 1% (0.03)	31.77 (27.72)	28.75 (23.13)	28.51 (22.78)	28.22 (22.36)	28.26 (22.42)
T10	Untreated control	31.52 (27.33)	32.54 (28.93)	33.66 (30.72)	34.81 (32.59)	36.01 (34.56)
S. Em. ± T (Treatments)		1.43	1.20	1.13	1.03	1.07
P (Period)		-	-	-	-	-
T × P		-	-	-	-	-
C.D. at 5% T		NS	3.54	3.34	3.05	3.16
P		-	-	-	-	-
T × P		-	-	-	-	-
C.V. (%)		7.99	7.67	7.41	6.87	6.89

*The figures in parentheses are retransformed values, those outside are arc sine transformed value

The pre-treatment observations on chiku moth damage recorded one day before the first spray were found to be non-significant. The mean percentage of chiku moth damage recorded at different intervals after spray of various treatments was computed to pooled over time.

The observations recorded at 1st day after first spray (Table 1) of bio-pesticides revealed that the treatment of NSKE 5% recorded the lowest damage (15.56%) which was statistically at par with treatment of *B. bassiana* 1.15 WP 0.0092%, *N. rileyi* 1.15 WP 0.0092% and *B. thuringiensis* 5

WP 0.01% with 16.00, 18.31 and 18.61% damage, respectively. The next best treatments were *B. bassiana* 1.15 WP 0.007%, *M. anisopliae* 1.15 WP 0.0092%, *M. anisopliae* 1.15 WP 0.007% and neemastra 1% with 20.33, 20.87, 22.84 and 23.13%, respectively. whereas, maximum damage due to chiku moth was recorded in the treatment of panchgavya 5% 0.04% with (24.05%) damage.

The observations recorded at 3rd day after first spray (Table 1) of bio-pesticides revealed that the treatment of NSKE 5% recorded the lowest damage of chiku moth (14.21%) which was statistically at par with treatment of *B. bassiana* 1.15 WP 0.0092%, *N. rileyi* 1.15 WP 0.0092%, *B. thuringiensis* 5 WP 0.010% with 14.54, 17.18 and 17.55% damage, respectively. The next best treatments were *B. bassiana* 1.15 WP 0.007%, *M. anisopliae* 1.15 WP 0.0092%, *B. bassiana* 1.15 WP 0.007%, *M. anisopliae* 1.15 WP 0.007% and neemastra 1% with 19.01, 19.10, 22.78% respectively, whereas, maximum damage due to chiku moth was recorded in the treatment of panchgavya 5% (23.40%).

The observations recorded at 7th day after first spray (Table 2) of bio-pesticides revealed that the treatment of NSKE 5% recorded the lowest damage (13.12%) which was statistically at par with treatment of *B. bassiana* 1.15 WP 0.0092%, *N. rileyi* 1.15 WP 0.0092% and *B. thuringiensis* 5 WP 0.010% with 13.27, 16.30 and 16.70% damage, respectively. It was followed by the treatment viz., *B. bassiana* 1.15 WP 0.007% (17.74%), *M. anisopliae* 1.15 WP 0.0092% (17.97%), *M. anisopliae* 1.15 WP 0.007% (22.14%) and neemastra 1% (22.36%), whereas, maximum damage due to chiku moth was recorded in the treatment of panchgavya 5% (22.93%).

The observations recorded at 10th day after first spray (Table 2) of bio-pesticides revealed that the NSKE 5% recorded the lowest damage (14.15%) which was statistically at par with treatment of *B. bassiana* 1.15 WP 0.0092%, *N. rileyi* 1.15 WP 0.0092% *B. thuringiensis* 5 WP 0.010% with 14.32, 17.79 and 18.53% damage, respectively. The next best treatments were *B. bassiana* 1.15 WP 0.007% (19.65%), *M. anisopliae* 1.15 WP 0.007% (20.03%) and Neemastra 1% (22.42%) damage, whereas, maximum damage due to chiku moth was recorded in the treatment of panchgavya 5% (23.43%).

The pooled data presented in (Table 2), indicates that all the bio-pesticidal treatments had significantly reduced the chiku moth damage. Among them, NSKE 5% was the most effective treatment resulting 14.25% damage and it was at par with treatment of *B. bassiana* 1.15 WP 0.0092% (14.52%), *N. rileyi* 1.15 WP 0.0092% (17.39%) and *B. t.* 5 WP 0.010 (17.84%). *B. bassiana* 1.15 WP 0.007% (19.17%), *M. anisopliae* 1.15 WP 0.0092% (19.48%), *M. anisopliae* 1.15 WP 0.007% (22.25%) and neemastra 1% (22.67%) were the next best treatments for reduction chiku moth damage, whereas, the least control was observed in the treatment of panchgavya% (23.43%).

Second spray

The observations recorded at 1st day after second spray (Table 3) of bio-pesticides revealed that NSKE 5%

treatment recorded the lowest damage of chiku (12.23%) but it was statistically at par with treatment of *B. t.* 5 WP 0.01%, *B. bassiana* 1.15 WP 0.0092%, and *N. rileyi* 1.15 WP 0.0092% which resulted 12.26, 11.87 and 12.81% damage, respectively. The ext best treatments were *B. bassiana* 1.15 WP 0.007%, *M. anisopliae* 1.15 WP 0.0092%, *M. anisopliae* 1.15 WP 0.007% and neemastra 1% with ranging from 14.90 to 17.90% damage, whereas, maximum damage due to chiku moth was recorded in the treatment of panchgavya 5% 0.04% (17.90%).

The observations recorded at 3rd day after second spray (Table 3) of bio-pesticides revealed that the treatment of NSKE 5% found superior and it was recorded lowest percent damage by chiku moth (9.64%), but it was statistically at par with treatment *B. bassiana* 1.15 WP 0.0092%, *B. thuringiensis* 5 WP 0.01% and *N. rileyi* 1.15 WP 0.0092% and resulted 10.46, 10.95 and 11.52% damage, respectively. The next best treatments were *B. bassiana* 1.15 WP 0.007%, *M. anisopliae* 1.15 WP 0.0092%, *M. anisopliae* 1.15 WP 0.007% and neemastra 1% with ranging from 14.03 to 17.00% damage, whereas, maximum damage due to chiku moth was recorded in the treatment of panchgavya 5% 0.015% (17.63%).

The observations recorded at 7th day after second spray (Table 3) of bio-pesticides revealed that the treatment of NSKE 5% recorded the lowest damage of chiku moth (7.95%) but it was statistically at par with treatment of *B. bassiana* 1.15 WP 0.0092%, *N. rileyi* 1.15 WP 0.0092% and *B. thuringiensis* 5 WP 0.01% resulted 8.31, 10.49 and 10.65% damage, respectively. It was followed by *B. bassiana* 1.15 WP 0.007% (13.68%), *M. anisopliae* 1.15 WP 0.0092% (13.96%), *M. anisopliae* 1.15 WP 0.007% (15.96%) and neemastra 1% (16.11%). whereas, maximum chiku moth damage was recorded in the treatment of pachgavya 5% 0.04% (16.40%).

The observations recorded at 10th day after second spray (Table 3) bio-pesticides revealed that the treatment of NSKE 5% recorded the lowest damage of chiku moth (8.70%) but it was statistically at par with treatment of *B. bassiana* 1.15 WP 0.0092%, *N. rileyi* 1.15 WP 0.0092% and *B. thuringiensis* 5 WP 0.01% resulted 8.83, 11.34 and 11.72% damage, respectively. The next best treatments in order i.e., *B. bassiana* 1.15 WP 0.007% (13.94%), *M. anisopliae* 1.15 WP 0.0092% (14.88%), *M. anisopliae* 1.15 WP 0.007% (16.22%) and neemastra 1% (17.07%). whereas, maximum damage due to chiku moth was recorded in the treatment of pachgavya 5% 0.04% (17.59%).

The pooled data presented in (Table 3), indicates that all the bio-pesticidal treatments reduced the chiku moth damage. Among them, NSKE 5% was the most effective treatment resulted 9.57% damage and it was at par with treatment of *B. bassiana* 1.15 WP 0.0092% (9.91%), *B. t.* 5 WP 0.010% (11.29%) and *N. rileyi* 1.15 WP 0.0092% (11.53%). Treatments *B. bassiana* 1.15 WP 0.007% (14.14%), *M. anisopliae* 1.15 WP 0.0092% (14.69%), *M. anisopliae* 1.15 WP 0.007% (15.49%) and neemastra 1% (17.07%) were found next best alternatives. Whereas, the least control was observed in the treatment of panchgavya 5% (17.38%).

Table 3: Efficacy of different Bio-pesticides against chiku moth, *N. eugraphella* infesting sapota (Second spray)

Tr. No.	Treatments	Twig damage (%)					
		Before spray	Days after spraying				Pooled over period
			1	3	7	10	
T ₁	<i>Beauveria bassiana</i> 1.15 WP (1 × 10 ⁸ CFU/g) (0.007)	25.98 (19.19)	22.71 (14.90)	22.00 (14.03)	21.71 (13.68)	21.92 (13.94)	22.09 (14.14)
T ₂	<i>Beauveria bassiana</i> 1.15 WP (1 × 10 ⁸ CFU/g) (0.0092)	25.63 (18.71)	20.50 (12.26)	18.87 (10.46)	16.75 (8.31)	17.29 (8.83)	18.35 (9.91)
T ₃	<i>Bacillus thuringiensis</i> 5 WP (1 × 10 ⁸ CFU/g) (0.01)	24.97 (17.82)	20.15 (11.87)	19.32 (10.95)	19.05 (10.65)	20.02 (11.72)	19.64 (11.29)
T ₄	<i>Metarhizium anisopilae</i> 1.15 WP (1×10 ⁸ CFU/g) (0.007)	24.71 (17.47)	23.04 (15.32)	22.36 (14.47)	23.55 (15.96)	23.75 (16.22)	23.18 (15.49)
T ₅	<i>Metarhizium anisopilae</i> 1.15 WP (1×10 ⁸ CFU/g) (0.0092)	26.29 (19.62)	23.16 (15.46)	22.51 (14.66)	21.80 (13.79)	22.69 (14.88)	22.54 (14.69)
T ₆	<i>Nomuraea rileyi</i> 1.15 WP (1 × 10 ⁸ CFU/g) (0.0092)	25.38 (18.37)	20.98 (12.81)	19.84 (11.52)	18.90 (10.49)	19.68 (11.34)	19.85 (11.53)
T ₇	NSKE 5% (0.015)	26.84 (20.39)	20.47 (12.23)	18.09 (9.64)	16.38 (7.95)	17.15 (8.70)	18.02 (9.57)
T ₈	Panchgavya 5% (0.0135)	25.98 (19.19)	25.03 (17.90)	24.83 (17.63)	23.89 (16.40)	24.80 (17.59)	24.64 (17.38)
T ₉	Neemastra 1% (0.03)	26.55 (19.88)	25.03 (17.90)	24.35 (17.00)	23.67 (16.11)	24.40 (17.07)	24.36 (17.07)
T ₁₀	Untreated control	25.89 (19.07)	26.54 (19.97)	28.05 (22.11)	28.59 (22.89)	29.27 (13.91)	28.11 (22.20)
S. Em. ± T (Treatments)		1.11	0.94	0.86	0.78	0.82	0.43
P (Period)		-	-	-	-	-	0.27
T × P		-	-	-	-	-	0.85
C.D. at 5% T		NS	2.76	2.55	2.31	2.42	1.20
P		-	-	-	-	-	NS
T × P		-	-	-	-	-	NS
C.V. (%)		7.51	7.12	6.80	6.34	6.42	6.69

*The figures in parantheses are retransformed values, those outside are arc sine transformed value

Conclusion

Among different nine bio-pesticides tested in field conditions against chiku moth at the Jambuvadi Farm Junagadh Agricultural University Junagadh, application of NSKE 5% was found to be the most effective treatment and it was at par with *B. bassiana* 1.15 WP 0.0092%, It was followed by *B. t.* 5 WP 0.01% and *N. rileyi* 1.15 WP 0.009%. Whereas, treatments *B. bassiana* 1.15 WP 0.007%, *M. anisopilae* 1.15 WP 0.0092%, *M. anisopilae* 1.15 WP 0.007% and neemastra 1% were the next best treatments, whereas the highest percent damage was observed in the treatment of panchgavya 5%.

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