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Bio-efficacy of insecticides, botanicals and biopesticide against the leaf eating caterpillar, *Noorda blitealis* Walker on drumstick

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Abstract: Drumstick is grown for pod as well as foliage yield and it is mainly attacked by leaf eating caterpillar *Noorda blitealis* Walker. Ten insecticides were tested against the defoliator, *N. blitealis.* Indoxacarb 15.8 EC @ 0.3 ml/l, emamectin benzoate 5 SG @ 0.25 g/l and fipronil 5 SC @ 1 ml/l were effective throughout the period of investigation being on par with each other but superior over thiodicarb 75 WP @ 2 g/l, NSKE @ 5%, *Beauveria bassiana* 1.15 SP @ 2 g/l, deltamethrin 2.8 EC @ 0.5 ml/l, malathion 50 EC @ 2 ml/l and dichlorvos 76 EC @ 0.5 ml/l. Significantly maximum leaf yield was obtained from the treatments indoxacarb 15.8 EC @ 0.3 ml/l, emamectin benzoate 5 SG @ 0.25 g/l and fipronil 5 SC @ 1 ml/l (28.55, 27.60 and 27.45 t/ha, respectively). The next best treatments were deltamethrin 2.8 EC @ 0.5 ml/l (18.63 t/ha), malathion 50 EC @ 2 ml/l (18.55 t/ha) and NSKE @ 5% (19.02 t/ha) and were on par with each other. The treatment indoxacarb 15.8 EC @ 0.3 ml/l recorded maximum additional yield (174 t/ha). Net return was highest in the treatment indoxacarb 15.8 EC @ 0.3 ml/l (₹ 87000 /ha). However, the higher incremental cost benefit ratio of 84.64 was obtained from the malathion 50 EC @ 2 ml/l followed by fipronil 5 SC @ 1 ml/l (71.25) and deltamethrin 2.8 EC @ 0.5 ml/l (56.81).

Key words: Biopesticide, Botanicals, Drumstick, Leaf eating caterpillar, New molecules

Introduction

Drumstick (*Moringa oleifera* Lamk.), a member of Moringaceae family, is one of the most popular vegetables in South India. The leaves are rich in protein, carotene, iron and ascorbic acid and they are used as vegetable. Like any other crop, drumstick trees are also vulnerable to the attack of number of insect pests and as many as 28 different insect species are recorded in India attacking at the various stages of this tree. The major destructive defoliator pests include leaf eating caterpillar, *Noorda blitealis* Walker, bud worm, *Noorda moringae* Tams, hairy caterpillar, *Eupterote mollifera* Walker and leaf feeding beetles, leaf eating weevils like *Myllocerus maculosus* Desb. The leaf eating caterpillar *N. blitealis* causes 100 per cent defoliation and hence it is a menace for the cultivation of moringa (Kalia and Joshi, 1997 and Munj *et al.,* 1998). The recorded hosts of this pest are entirely restricted to the plant family Moringaceae (Demuelenaere, 2001; Parrott, 2001 and Anon., 2012).

Material and methods

A field experiment was conducted during October to November 2013 in an established two year old drumstick (cv. Bhagya) garden at Udyanagiri campus, College of Horticulture, UHS, Bagalkot, which had enough infestation of leaf eating caterpillar to evaluate the relative efficacy of insecticides, botanicals and biopesticide. The experiment was laid out in a randomized complete block design with 11 treatments along with three replications. The details of the treatment are given in Table 1 and each plant formed a treatment unit. The treatments were randomly assigned to individual plants. The first spray was given as and when damage by leaf eating caterpillar crossed 10 per cent and subsequent two sprays were also taken on the basis of damage by the leaf eating caterpillar. The average of five branches *viz.,* four branches from four different directions and one from the middle, was considered for assessing the bio-efficacy of different insecticides. In each branch, the number of caterpillars found feeding was assessed just before imposing treatment and after one, three, seven and fifteen day of the treatment. Similar procedure was adopted before and after second and third schedule of treatments at 15 day interval. Data thus obtained were subjected to square root transformation for the statistical analysis.

Results and discussion

The number of larvae of *N. blitealis* ranged from 2.66 to 15.67 per branch before spray but there was no significant difference among the treatment plots. Further, the observations on the number of larvae after the treatments are presented in Table 1.

One day after the first spray, among the different insecticides evaluated, fipronil 5 SC @ 1 ml/l (0.00 larva/branch), emamectin benzoate 5 SG @ 0.25 g/l (0.67 larva/branch), thiodicarb 75 WP @ 2 g/l (0.67 larva/branch), indoxacarb 15.8 EC @ 0.3 ml/l (3.00 larvae/branch), *Beauveria bassiana* 1.15 SP @ 2 g/l (2.67 larvae/branch) and deltamethrin 2.8 EC @ 0.5 ml/l (5.00 larvae/branch) were significantly superior over the other treatments and untreated control (13.34 larvae/branch) and they were at par with each other. Malathion 50 EC @ 2 ml/l (9.67 larvae/branch), azadirachtin 1000 ppm @ 3 ml/l (12.67 larvae/branch) and NSKE @ 5% (13.00 larvae/branch) were at par with untreated control. On the third day after first spray, emamectin benzoate 5 SG @ 0.25 g/l, fipronil 5 SC @ 1 ml/l, thiodicarb 75 WP @ 2 g/l, indoxacarb 15.8 EC @ 0.3 ml/l, dichlorvos 76 EC @ 0.5 ml/l, malathion 50 EC @ 2 ml/l and *B. bassiana* 1.15 SP @ 2 g/l were at par with each other by recording the larval population of 0.34, 0.67, 1.00, 1.34, 2.34, 2.34 and 3.00 larvae per branch, respectively. The highest mean number of larvae per branch was recorded from untreated plot

Table 1. Bio efficacy of different insecticides, botanicals and biopesticides after different sprays against the drumstick leaf eating caterpillar, *Noorda blitealis*

Treatments	Dosage	No. of larvae per branch at different sprays												
			I Spray				II Spray				III Spray			
		Before spray	1 DAS	3 DAS	7 DAS	15 DAS	1 DAS	3 DAS	7 DAS	15 DAS	1 DAS	3 DAS	7 DAS	15 DAS
Deltamethrin 2.8 EC	0.5 ml/l	11.00	5.00	3.00	3.00	1.00	12.67	8.67	10.00	5.34	3.34	9.34	3.67	3.34
		(2.53)	(2.09)^{cde}	(1.86)^{cde}	(1.70)^{cd}	(1.09)^{de}	(3.60)^{bc}	(2.98)^{abc}	(2.95)^{ab}	(2.16)^{b}	(1.77)^{de}	(2.95)^{ab}	(2.10)^{bc}	(1.76)^{cde}
Fipronil 5 SC	1 ml/l	6.33	0.00	0.67	1.00	0.34	0.00	0.00	1.67	0.00	2.67	1.34	0.00	1.67
		(2.28)	(0.72)^{e}	(1.05)^{de}	(1.18)^{d}	(0.87)^{e}	(0.72)^{f}	(0.72)^{e}	(1.35)^{bcd}	(0.72)^{c}	(1.73)^{e}	(1.16)^{c}	(0.72)^{e}	(1.35)^{de}
Emamectin benzoate 5SG	0.25 g/l	12.34	0.67	0.34	1.00	0.00	1.34	3.02	0.00	0.00	3.34	3.00	2.34	0.67
		(3.53)	(1.00)^{de}	(0.87)^{e}	(1.18)^{d}	(0.72)^{e}	(1.16)^{ef}	(1.88)^{cde}	(0.72)^{d}	(0.72)^{c}	(1.77)^{e}	(1.76)^{bc}	(1.55)^{cd}	(0.95)^{e}
Indoxacarb 15.8 EC	0.3 ml/l	15.67	3.00	1.34	1.67	0.00	3.67	3.00	1.34	1.00	4.00	0.67	0.34	1.00
		(3.87)	(1.88)^{cde}	(0.93)^{c}	(1.42)^{cd}	(0.72)^{e}	(2.09)^{def}	(1.72)^{cde}	(1.16)^{cd}	(1.18)^{bc}	(2.15)^{cde}	(1.05)^{c}	(0.87)^{de}	(1.17)^{e}
Dichlorvos 76 EC	0.5 ml/l	11.00	6.00	2.34	8.67	3.67	10.00	11.34	5.34	5.00	14.34	10.34	6.67	10.34
		(2.89)	(2.30)^{bcd}	(1.26)^{de}	(2.95)^{b}	(1.96)^{cd}	(3.02)^{bcd}	(3.32)^{ab}	(2.33)^{abc}	(1.78)^{bc}	(3.79)^{bc}	(3.27)^{ab}	(2.66)^{ab}	(3.29)^{abc}
Azadirachtin 1000 ppm	3 ml/l	2.66	12.67	11.00	3.34	9.34	17.34	10.67	4.00	5.10	12.34	10.67	7.34	9.00
		(1.43)	(3.60)^{ab}	(3.36)^{ab}	(2.44)^{bc}	(3.06)^{b}	(4.12)^{ab}	(3.30)^{ab}	(2.09)$^{a-d}$	(2.33)^{ab}	(3.46)^{bc}	(3.10)^{ab}	(2.78)^{ab}	(2.98)$^{a-d}$
Thiodicarb 75 WP	2 g/l	10.00	0.67	1.00	4.34	0.34	6.34	1.00	3.00	2.34	12.34	5.67	4.67	12.34
		(3.25)	(1.05)^{de}	(1.18)^{de}	(2.10)^{bcd}	(0.87)^{e}	(2.15)^{de}	(1.80)^{de}	(1.67)^{bcd}	(1.55)^{bc}	(3.24)$^{b-e}$	(2.36)^{abc}	(2.18)^{bc}	(3.39)^{ab}
NSKE	5%	6.33	13.00	5.67	3.34	1.00	5.00	5.00	1.67	1.67	23.34	12.67	5.34	11.34
		(2.17)	(3.53)^{ab}	(2.48)^{bc}	(1.90)^{bcd}	(1.18)^{de}	(2.28)^{de}	(2.13)^{bcd}	(1.34)^{bcd}	(1.34)^{bc}	(4.14)^{ab}	(3.55)^{a}	(2.38)^{bc}	(3.34)^{ab}
Beauveria bassiana 1.15SP	2 g/l	8.67	2.67	3.34	2.34	5.00	8.34	11.34	4.67	2.00	15.67	12.00	5.67	8.00
		(2.41)	(1.71)^{cde}	(1.94)^{cd}	(1.65)^{cd}	(2.36)^{bc}	(2.83)^{bcd}	(3.49)^{ab}	(2.23)$^{a-d}$	(1.50)^{bc}	(3.98)^{ab}	(3.47)^{a}	(2.49)^{ab}	(2.72)^{bcd}
Malathion 50 EC	2 ml/l	14.33	9.67	2.34	4.00	1.67	5.34	5.34	3.00	3.34	11.67	10.67	8.00	3.67
(Standard Check)		(3.85)	(3.07)^{abc}	(1.59)^{cde}	(2.22)^{bcd}	(1.35)^{cde}	(2.32)^{cde}	(2.32)^{bcd}	(1.49)^{bcd}	(1.94)^{bc}	(3.44)^{bcd}	(3.20)^{ab}	(2.84)^{ab}	(1.73)^{cde}
Untreated control	-	9.00	13.34	15.00	21.34	22.67	25.00	18.00	13.34	13.00	30.67	13.67	11.00	19.34
		(2.44)	(3.76)^{a}	(3.95)^{a}	(4.65)^{a}	(4.78)^{a}	(5.02)^{a}	(4.20)^{a}	(3.66)^{a}	(3.54)^{a}	(5.56)^{a}	(3.77)^{a}	(3.29)^{a}	(4.45)^{a}
S.Em.±			0.458	0.348	0.340	0.327	0.447	0.468	0.540	0.434	0.563	0.567	0.290	0.543
C.D. at 5%		NS	1.356	0.992	1.066	0.962	1.323	1.371	1.598	1.289	1.660	1.702	0.850	1.594

Means followed by same alphabet (s) do not differ significantly by DMRT (p=0.05), NS- Non Significant, DAS- Days after spray

Figures in the parentheses indicate $\sqrt{x+0.5}$ transformations

(15.00 larvae/branch) which was at par with azadirachtin 1000 ppm @ 3 ml/l (11.00 larvae/branch). At seven days after the first spray, all the treatments were superior over the untreated control. The lowest larval population of 1.00 per branch was recorded in plots treated with fipronil 5 SC @ 1 ml/l and emamectin benzoate 5 SG @ 0.25 g/l and these treatments were significantly superior over other treatments. The treatment of indoxacarb 15.8 EC @ 0.3 ml/l, *B. bassiana* 1.15 SP @ 2 g/l, deltamethrin 2.8 EC @ 0.5 ml/l, NSKE @ 5%, azadirachtin 1000 ppm @ 3 ml/l and malathion 50 EC @ 2 ml/l were at par with each other by recording the larval population of 1.67, 2.34, 3.00, 3.34, 3.34 and 4.00 larvae per branch, respectively. The highest mean number of 21.34 larvae per branch was recorded from untreated plot. At fifteen days after the first spray, lower larval population was recorded in the plots treated with indoxacarb 15.8 EC @ 0.3 ml/l, emamectin benzoate 5 SG @ 0.25 g/l, fipronil 5 SC @ 1 ml/l, thiodicarb 75 WP @ 2 g/l, deltamethrin 2.8 EC @ 0.5 ml/l, NSKE @ 5% and malathion 50 EC @ 2 ml/l and these treatments were significantly superior over remaining treatments *viz.,* dichlorvos 76 EC @ 0.5 ml/l, *B. bassiana* 1.15 SP @ 2 g/l and azadirachtin 1000 ppm @ 3 ml/l. The highest larval population was recorded from the untreated plot.

On the first day after second spray, fipronil 5 SC @ 1 ml/l was found to be the most effective treatment and was at par with emamectin benzoate 5 SG @ 0.25 g/l (1.34 larvae/branch), indoxacarb 15.8 EC @ 0.3 ml/l (3.67 larvae/branch), NSKE @ 5% (5.00 larvae/branch) and thiodicarb 75 WP @ 2 g/l (6.34 larvae/branch). The highest number of larvae per branch was recorded in azadirachtin (17.34 larvae/branch) and it was at par with untreated control (25.00 larvae /branch). On the third day after second spray, significantly less larval population was recorded in the treatment of fipronil 5 SC @ 1 ml/l and it was at par with thiodicarb 75 WP @ 2 g/l, indoxacarb 15.8 EC @ 0.3 ml/l and emamectin benzoate 5 SG @ 0.25 g/l. The treatments of azadirachtin 1000 ppm @ 3 ml/l, dichlorvos 76 EC @ 0.5 ml/l and *B. bassiana* 1.15 SP @ 2 g/l were on at par with untreated control. At seven days after the second spray, significantly less larval population was recorded from the treatment of emamectin benzoate 5 SG @ 0.25 g/l (zero larva/branch) and it was at par with the treatments of indoxacarb 15.8 EC @ 0.3 ml/l, NSKE @ 5%, fipronil 5 SC @ 1 ml/l, malathion, and thiodicarb 75 WP @ 2 g/l by recording the larval population of 1.34, 1.67, 1.67, 3.00 and 3.00 larvae per branch, respectively. Higher larval population was recorded in deltamethrin 2.8 EC @ 0.5 ml/l (10.00 larva/branch), *B. bassiana* 1.15 SP @ 2 g/l (4.67 larvae/branch) and azadirachtin 1000 ppm @ 3 ml/l (4.00 larvae/branch) and they were at par with untreated control. At fifteen days after the second spray, fipronil 5 SC @ 1 ml/l and emamectin benzoate 5 SG @ 0.25 g/l were significantly superior (mil larval population) and were at par with indoxacarb 15.8 EC @ 0.3 ml/l, NSKE @ 5%, *B. bassiana* 1.15 SP @ 2 g/l, thiodicarb 75 WP @ 2 g/l, malathion 50 EC @ 2 ml/l and dichlorvos 76 EC @ 0.5 ml/l and they were superior over the control.

A day after the third spray, fipronil 5 SC @ 1 ml/l, emamectin benzoate 5 SG @ 0.25 g/l and deltamethrin 2.8 EC @ 0.5 ml/l were at par. While indoxacarb 15.8 EC @ 0.3 ml/l, malathion 50 EC @ 2 ml/l, thiodicarb 75 WP @ 2 g/l, azadirachtin 1000 ppm @ 3 ml/l and dichlorvos 76 EC @ 0.5 ml/l were at par with each other. The highest larval population was recorded in untreated plot (30.67 larvae/branch) and it was at par with NSKE @ 5% and *B. bassiana* 1.15 SP @ 2 g/l. On the third day of third spray, indoxacarb 15.8 EC @ 0.3 ml/l and fipronil 5 SC @ 1 ml/l recorded significantly less larval population of 0.67 and 1.34 larvae per branch, respectively and were at par with emamectin benzoate 5 SG @ 0.25 g/l and thiodicarb 75 WP @ 2 g/l. The remaining treatments were at par with control. On the seventh day after the third spray, fipronil 5 SC @ 1 ml/l recorded significantly, the lowest larval population (zero of larva/branch) and was at par with indoxacarb 15.8 EC @ 0.3 ml/l. The next best treatment in recording lowest larval population was emamectin benzoate 5 SG @ 0.25 g/l, which was at par with deltamethrin 2.8 EC @ 0.5 ml/l, thiodicarb 75 WP @ 2 g/l and NSKE @ 5% (3.67, 4.67 and 5.34 larvae/branch, respectively). The treatments of malathion 50 EC @ 2 ml/l (8.00 larvae/branch), azadirachtin 1000 ppm @ 3 ml/l (7.34 larva/branch), dichlorvos 76 EC @ 0.5 ml/l (6.67 larvae/branch) and *B. bassiana* (5.67 larvae/branch) were at par with untreated control (11.00 larvae/branch). At the fifteen days after the third spray, the lowest larval population was recorded from the treatments of emamectin benzoate 5 SG @ 0.25 g/l and indoxacarb 15.8 EC @ 0.3 ml/l and next best treatments were fipronil 5 SC @ 1 ml/l, deltamethrin 2.8 EC @ 0.5 ml/l and malathion 50 EC @ 2 ml/l. David and Kumarswamy (1982) recommended the spraying of malathion 0.1 per cent for the control of *N. blitealis*. Honnalingappa (2001) reported that NSKE and neem oil were effective in controlling the leaf eating caterpillar. More or less similar results were also reported by Satti *et al.* (2013).

All the insecticides, including standard check, evaluated against drumstick leaf eating caterpillar brought a significant reduction in larval population as compared to untreated control. Among the ten insecticide fipronil 5 SC @ 1 ml/l, emamectin benzoate 5 SG @ 0.25 g/l and indoxacarb 15.8 EC @ 0.3 ml/l were significantly superior throughout the period of investigation and they were at par with each other followed by thiodicarb 75 WP @ 2 g/l, NSKE @ 5%, *B. bassiana*, deltamethrin 2.8 EC @ 0.5 ml/l, malathion 50 EC @ 2 ml/l and dichlorvos 76 EC @ 0.5 ml/l. Ragumoorthi and Arumugam (1992) indicated that dichlorvos (0.04%) and fenthion (0.04%) were the most effective and showed cent per cent reduction in the larval population of *N. blitealis* upto 21 days after spray as compared to control.

The fresh leaf yield ranged from 11.15 to 28.55 t/ha. Significantly higher leaf yield was obtained from the treatments of indoxacarb 15.8 EC @ 0.3 ml/l, emamectin benzoate 5 SG @ 0.25 g/l and fipronil 5 SC @ 1 ml/l (28.55, 27.60 and 27.45 t/ha, respectively). The next better treatments were NSKE @ 5% (19.02 t/ha), deltamethrin 2.8 EC @ 0.5 ml/l (18.63 t/ha) and malathion 50 EC @ 2 ml/l (18.55 t/ha) and were at par with each other. Other treatments by dichlorvos 76 EC @ 0.5 ml/l (16.03 t/ha), *B. bassiana* 1.15 SP @ 2 g/l (14.98 t/ha), thiodicarb 75 WP @ 2 g/l (13.87 t/ha) and azadirachtin 1000 ppm @ 3 ml/l (12.70 t/ha) were also found to be superior over untreated control (11.15 t/ha) (Table 2).

Table 2. Marketable fresh leaf yield and economics of drumstick as influenced by management of leaf eating caterpillar, *Noorda blitealis*

Treatments	Dosage	Leaf yield (kg/tree)	Leaf yield (t/ha)	Gross returns (₹/ha)	Incremental yield over control (t/ha)	Incremental return over control (₹/ha)	*Cost of plant protection (₹/ha)	Additional net profit (₹/ha)	ICBR
Deltamethrin 2.8 EC	0.5 ml/l	1.87^{b}	18.63^{b}	93150	74	37400	640	36760	57.43
Fipronil 5 SC	1 ml/l	2.75^{a}	27.45^{a}	137250	163	81500	1128	80372	71.25
Emamectin benzoate 5 SG	0.25 g/l	2.73^{a}	27.60^{a}	138000	164.5	82250	5960	76290	12.80
Indoxacarb 15.8 EC	0.3 ml/l	2.85^{a}	28.55^{a}	142750	174	87000	3512	83488	23.77
Dichlorvos 76 EC	0.5 ml/l	1.60^{c}	16.03^{c}	80150	48.8	24400	760	23640	31.10
Azadirachtin 1000 ppm	3 ml/l	1.27^{de}	12.70^{de}	63500	15.5	7750	1120	6630	5.91
Thiodicarb 75 WP	2 g/l	1.34^{de}	13.87^{de}	69350	27.2	13600	512	13088	25.56
NSKE	5%	1.90^{b}	19.02^{b}	95100	78.7	39350	3400	35950	10.57
Beauveria bassiana 1.15 SP	2 g/l	1.49^{cd}	14.98^{cd}	74900	38.3	19150	600	18550	30.91
Malathion 50 EC (Standard Check)	2 ml/l	1.87^{b}	18.55^{b}	92750	74	37000	432	36568	84.64
Untreated control	-	1.12^{e}	11.15^{e}	55750	-	-	-	-	-
S.Em.±	-	0.091	0.846	-	-	-	-	-	-
C.D. at 5%	-	0.248	2.490	-	-	-	-	-	-

*Means followed by same alphabet (s) do not differ significantly by DMRT (p=0.05)

Market price of leaves was ₹ 5/kg

*Cost of treatment with insecticide + Cost of application

ICBR= Incremental cost benefit ratio

The treatment of indoxacarb 15.8 EC @ 0.3 ml/l recorded the maximum additional yield (174 t/ha). The other treatments *viz.,* emamectin benzoate 5 SG @ 0.25 g/l (164.5 t/ha), fipronil 5 SC @ 1 ml/l (163 t/ha), NSKE (78.7 t/ha), deltamethrin 2.8 EC @ 0.5 ml/l (74 t/ha) and malathion 50 EC @ 2 ml/l (74 t/ha) also gave higher additional yield over untreated control.

Additional net profits were the highest in the treatment of indoxacarb 15.8 EC @ 0.3 ml/l (₹ 83488). Other treatments *viz.,* fipronil 5 SC @ 1 ml/l (₹ 80372), emamectin benzoate 5 SG @ 0.25 g/l (₹ 76290), deltamethrin 2.8 EC @ 0.5 ml/l (₹ 36760), malathion 50 EC @ 2 ml/l (₹ 36568) and NSKE @ 5% (₹ 35950). However, the highest incremental cost benefit ratio of 84.64 was obtained from the treatment of malathion 50 EC @ 2 ml/l followed by fipronil 5 SC @ 1 ml/l (71.25) and deltamethrin 2.8 EC @ 0.5 ml/l (57.43). Even though higher net profits were obtained from the treatments emamectin benzoate 5 SG @ 0.25 g/l and indoxacarb 15.8 EC @ 0.3 ml/l, ICBR was low due to higher cost of insecticide as compared with malathion 50 EC @ 2 ml/l.

It is evident from the study that the insecticide treatments were highly effective against drumstick leaf eating caterpillar for getting more marketable leaf yield. Particularly the insecticides *viz.,* emamectin benzoate 5 SG @ 0.25 g/l, indoxacarb 15.8 EC @ 0.3 ml/l and fipronil 5 SC @ 1 ml/l could be suggested to drumstick growers for the effective management of leaf eating caterpillar and to get better marketable leaf yield. However, the repetition of this study along with the residual toxicity of these insecticides needs to be made further before the final recommendation to the farmers.

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