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Bio-efficacy of eco-friendly insecticides against pests of Indian bean, *Lablab purpureus* L.

Indian bean, *Lablab purpureus* L. the important legume crop of Gujarat is attacked by various pests. Among the various sucking pests, the aphid, *Aphis craccivora* Koch, leafhopper, *Empoasca kerri* Pruthi, whitefly, *Bemisia tabaci* Genn. and thrips, *Megaleurothrips distalis* Karny and among the pod borer, *Helicoverpa armigera* (Hubner) Hardwick are causing economic damage. Indian bean being used as vegetable, the use of chemical pesticides is not advisable because of their residue in pods. Therefore, an attempt was made to evaluate ecofriendly insecticides are an alternative to chemical pesticides.

A field experiment on evaluation of relative bio-efficacy of nine different ecofriendly insecticides (Table 1) was conducted at Agronomy farm, Anand Agricultural University, Anand (Gujarat) during the year 2010-11. The experiment was laid out in Randomized Block Design replicated thrice. The gross and net plot size was 4.5 x 3.6 m and 2.7 x 1.8 m, respectively. Seeds of Indian bean (Gujarat papdi-1) were dibbled at 90 x 45 cm spacing during last week of November 2010. As and when required all the agronomical practices were followed, except plant protection. Considering the pest population in experimental area, two sprays were applied on need basis.

In order to record the population of various insect pests, five plants were selected randomly from net plot area of each plot and tagged. The observations were recorded prior and 5, 7 and 10 days after each spray. Aphid, *A. craccivora* population was recorded on three randomly selected twigs (about 10 cm in length) from each tagged plant and mean number of aphids per twig was worked out. For leaf hopper, *E. kerri* and whitefly, *B. tabaci*, three leaves (top, middle and bottom) of each tagged plant were counted and mean number of each sucking insect per leaf were computed. Population of thrips was assessed by shaking flowers with twigs over a white paper and counted the total number of thrips fallen on the paper piece. Mean number of thrips per flower was calculated by dividing the total count by total number of flowers present in the twig. Number of pod borer, *H. armigera* larvae present on tagged plants in each plot were recorded and mean numbers of larvae per plant were calculated. Yield of green pods was recorded plot-wise during each picking and then converted to kg per hectare. Incremental Cost Benefit Ratio (ICBR) for each treatment was worked out based on prevailing market price of insecticides and produce.

The data (Table 1) on aphid population recorded during first spray indicated that the plots treated with Neem Seed Kernel Extract (NSKE) registered minimum (13.19 aphids / twig) population of the pest followed by neem leaves extract (13.74 aphids / twig), neem oil (14.52 aphids /twig) and *Metarhizium anisopliae* (16.78 aphids /twig). Remaining insecticides proved inferior in controlling the aphid population and found at par. Superiority of NSKE, neem leaves extract (NLE) and neem oil in suppressing the aphid population was also found during second spray. Pooled over spray data revealed least (12.03 aphids per twig) number of aphids in NSKE followed by NLE (12.68 aphids / twig) and neem oil (14.25 aphids / twig). Among the microbial insecticides, *M. anisopliae* registered significantly least population of aphids (15.18 aphids / twig). Plots sprayed with *Beaveria bassiana, Lecanicillium lecanii* and *Nomurea rilleyi* exhibited aphid population ranging from 24.01 to 26.23 aphids per twig and found moderately effective against aphid. Results concluded that the treatments of NSKE and NLE proved effective in mitigating the incidence of aphid, *A. craccivora* which is in conformity with the report of Dalwadi *et al.* (2008) and Egho (2011). These workers have showed the effectiveness of NSKE against *A. craccivora* infesting cowpea and Indian bean.

Population of leafhopper (*E. kerri*) reduced significantly in the plots treated with NSKE, NLE and neem oil over rest of the insecticides (Table 1). *M. anisopliae* also found to be better product in suppressing the pest and stood next to botanical products (Prajapati *et at.,* 2003). The *L. lecanii, B. bassiana* and *N. rileyi* found at par with spinosad. Similar trend of treatment effect was revealed during second spray wherein significantly lower (1.20 to 1.65 hoppers/leaf) population of leafhopper was found in NSKE, NLE and neem oil than rest of the insecticides, except *M. anisopliae.* Pooled data indicated that the plots treated with NSKE exhibited minimum (1.16 hoppers/leaf) count of hoppers followed by neem oil (1.32 hoppers/leaf) and NLE (1.43 hoppers/leaf). These plant products proved significantly better than microbial insecticides. Better performance of NSKE and NLE against *E. kerri* observed in present study is in close concurrence with the finding of Dalwadi *et al.* (2008), whereas better performance of *M. anisopliae* to this pest revealed in present investigation is in accordance with the report of Naik and Shekharappa (2009) who reported that the oil based formulation of *M. anisopliae* recorded minimum hopper population in okra.

Whitefly, *B. tabaci* count recorded during first spray (Table 1) showed that its population was significantly lower (0.84 to 1.04 whiteflies/leaf) in plots treated with botanical products than rest of the insecticides. Entomopathogenic fungi also found to be better treatments in suppressing the whitefly population. Effectiveness of botanical products against *B. tabaci* also found during second spray. Pooled data indicated that the plots treated with these botanical products registered significantly lower (0.75 to 0.89 whitefly/leaf) incidence of the pest than rest of the insecticides (2.03 to 4.34 whiteflies/leaf). All the four microbial insecticides found equally effective and proved mediocre in their effect against whitefly.

Among the various eco-friendly treatments evaluated, the plots sprayed with NLE, NSKE and neem oil registered significantly lower (1.17 to 1.31 thrips/flower) population of thrips, *M. distalis* during first spray (Table 1). The *M. anisopliae, B. basiana* and *L. lecanii* found moderately, while *N. rileyii,* spinosad and emamectin benzoate proved relatively less effective against this pest. More or less similar trend of treatment effect was observed during second spray. Pooled data computed for two sprays indicated that the plots treated with NSKE, NLE and neem oil exhibited significantly lesser (1.30 to 1.46 thrips/flower) number of thrips in comparison to

Table 1. Effect of various eco-friendly insecticides on sucking pests infesting Indian bean

Treatments	Aphid/twig			Leafhopper/leaf			Whitefly/leaf			Thrips/flower		
	I spray	II spray	Pooled	I spray	II spray	Pooled	I spray	II spray	Pooled	I spray	II spray	Pooled
Beauveria bassiana	5.31^{b}	4.71^{b}	5.01^{c}	1.85^{c}	1.81^{cd}	1.83^{c}	1.84^{b}	1.65^{bc}	1.74^{b}	1.83^{b}	1.77^{b}	1.80^{b}
(2x10^{8} cfu/g) @ 1.5 kg/ha	(27.74)	(21.69)	(24.60)	(2.93)	(2.77)	(2.85)	(2.87)	(2.21)	(2.53)	(2.84)	(2.64)	(2.74)
Lecanicillium lecanii	5.35^{b}	4.77^{b}	5.06^{c}	1.85^{c}	1.86^{cd}	1.85^{c}	1.83^{b}	1.75^{c}	1.79^{bc}	1.87^{b}	1.83^{b}	1.85^{b}
(2x10^{8} cfu/g) @ 1.5 kg/ha	(28.07)	(22.23)	(25.10)	(2.91)	(2.97)	(2.92)	(2.84)	(2.55)	(2.70)	(2.98)	(2.84)	(2.92)
Metarhizium anisopliae	4.16^{a}	3.77^{a}	3.96^{b}	1.57^{b}	1.62^{bc}	1.59^{b}	1.68^{b}	1.50^{b}	1.59^{b}	1.78^{b}	1.84^{b}	1.81^{b}
(2x10^{8} cfu/g) @ 1.5 kg/ha	(16.78)	(13.68)	(15.18)	(1.96)	(2.11)	(2.03)	(2.31)	(1.73)	(2.03)	(2.66)	(2.90)	(2.78)
Nomurea rileyi	5.50^{b}	4.85^{b}	5.17^{cd}	1.95^{c}	1.95^{d}	1.95^{c}	2.17^{c}	1.80^{cd}	1.98^{cd}	2.19^{c}	2.09^{c}	2.14^{c}
(2x10^{8} cfu/g) @ 1.5 kg/ha	(29.72)	(22.98)	(26.23)	(3.29)	(3.31)	(3.30)	(4.20)	(2.73)	(3.42)	(4.31)	(3.88)	(4.08)
Neem seed kernel extract	3.70^{a}	3.39^{a}	3.54^{a}	1.27^{a}	1.31^{a}	1.29^{a}	1.16^{a}	1.09^{a}	1.12^{a}	1.32^{a}	1.36^{a}	1.34^{a}
@ 5 %	(13.19)	(10.99)	(12.03)	(1.12)	(1.20)	(1.16)	(0.84)	(0.68)	(0.75)	(1.24)	(1.36)	(1.30)
Neem leaf extract @ 10 %	3.77^{a}	3.49^{a}	3.63^{ab}	1.32^{a}	1.47^{ab}	1.39^{a}	1.24^{a}	1.11^{a}	1.18^{a}	1.29^{a}	1.40^{a}	1.35^{a}
	(13.74)	(11.69)	(12.68)	(1.24)	(1.65)	(1.43)	(1.04)	(0.73)	(0.89)	(1.17)	(1.46)	(1.32)
Neem oil @ 0.5 %	3.88^{a}	3.80^{a}	3.84^{ab}	1.37^{a}	1.34^{a}	1.35^{a}	1.19^{a}	1.16^{a}	1.17^{a}	1.35^{a}	1.45^{a}	1.40^{a}
	(14.52)	(13.90)	(14.25)	(1.36)	(1.29)	(1.32)	(0.91)	(0.85)	(0.87)	(1.31)	(1.60)	(1.46)
Spinosad 45 SC (0.015 %)	5.92^{b}	4.97^{b}	5.45^{d}	1.99^{cd}	1.96^{d}	1.97^{c}	2.16^{c}	1.95^{de}	2.05^{d}	2.21^{c}	2.15^{c}	2.18^{c}
	(34.57)	(244.19)	(29.20)	(3.44)	(3.35)	(3.38)	(4.15)	(3.29)	(3.70)	(4.38)	(4.11)	(4.25)
Emamectin benzoate 5	5.90^{b}	5.16^{b}	5.53^{d}	2.03^{d}	1.97^{d}	2.00^{c}	2.31^{c}	2.08^{e}	2.20^{d}	2.27^{c}	2.18^{c}	2.22^{c}
SG (0.0025 %)	(34.25)	(26.13)	(30.08)	(3.63)	(3.37)	(3.50)	(4.84)	(3.83)	(4.34)	(4.63)	(4.24)	(4.42)
Control (water spray)	7.45^{c}	6.49^{c}	6.97^{e}	2.37^{e}	2.41^{e}	2.39^{d}	2.62^{d}	2.61^{f}	2.62^{e}	2.46^{d}	2.71^{d}	2.58^{d}
	(54.97)	(41.61)	(48.08)	(5.13)	(5.28)	(5.21)	(6.36)	(6.33)	(6.36)	(5.13)	(6.84)	(6.16)
S.Em± : Treatment (T)	0.32	0.16	0.12	0.05	0.09	0.06	0.07	0.06	0.07	0.06	0.06	0.06
Period (P)	-	-	0.06	-	-	0.02	-	-	0.03	-	-	0.02
Spray (S)	-	-	0.05	-	-	0.02	-	-	0.02	-	-	0.02
T x P	-	-	0.16	-	-	0.05	-	-	0.07	-	-	0.06
T x S	-	-	0.09	-	-	0.03	-	-	0.04	-	-	0.03
P x S	-	-	0.19	-	-	0.06	-	-	0.08	-	-	0.07
T x P x S	-	-	0.27	-	-	0.08	-	-	0.11	-	-	0.10
C.D. at 5% : T	0.95	0.46	0.36	0.15	0.26	0.18	0.21	0.18	0.22	0.18	0.19	0.18
P	-	-	0.17	-	-	0.05	-	-	0.07	-	-	0.07
S	-	-	0.14	-	-	0.14	-	-	0.06	-	-	NS
T x P	-	-	0.44	-	-	NS	-	-	NS	-	-	NS
T x S	-	-	NS	-	-	NS	-	-	NS	-	-	NS
P x S	-	-	NS	-	-	0.17	-	-	NS	-	-	NS
T x P x S	-	-	NS	-	-	NS	-	-	NS	-	-	NS
C.V. (%)	9.14	9.99	9.70	9.49	9.51	8.20	11.50	12.93	13.10	10.84	10.38	9.71

*Figures are $\sqrt{x + 0.5}$ transformed values and those in parentheses are re-transformed values. NS = Not significant
Treatment means with letter(s) in common are not significant by DNMRT at 5 % level of significance

plots treated with rest of the insecticides. Microbial insecticides also proved better and stood next to botanicals. The efficiency of NSKE and NLE in suppressing the population of *M. distalis* on Indian bean noticed in present study is in close agreement with the finding of Dalwadi *et al.* (2008).

The plots treated with emamectin benzoate and spinosad (used as recommended check) registered significantly lesser (0.19 to 0.22 larva/plant) numbers (Table 2). Plots treated with NSKE and neem oil showed 0.50 and 0.68 larva/plant, respectively. These two botanicals found significantly superior over microbial insecticides. Plots sprayed with emamectin benzoate, spinosad and NSKE exhibited significantly lesser (28.87 to 30.56 %) number of damaged pods due to *H. armigera* in comparison to rest of the other insecticides, except neem oil. NSKE proved significantly superior over NLE. Microbial insecticides failed to control the pod borer incidence. However, *N. rilleyii* found to be better product of microbial insecticides which was at par with neem oil and NLE. Effectiveness of NSKE and neem oil in reducing the larval population of *H. armigera* revealed in present study is in agreement with the finding of Dalwadi *et al.* (2008) and Srinivasan and Sridhar (2008) who showed effectiveness of these botanical products against pod borer (*Maruca vitrata*) infesting leguminous crops.

Data on green pod yield (Table 3) indicated that the treatments of emamectin benzoate and spinosad as synthetic insecticides based on microorganism produced significantly higher (3326 to 3477 kg/ha) pod yield in comparison to other biopesticides. The report of Kambrekar *et al.* (2012) and Dalwadi *et al.* (2008) are in close conformity with the present finding. Fungal based microbial insecticides produced poor yield (2119 to 2332 kg/ha).

Maximum (1:44.14) Incremental Cost Benefit Ratio (ICBR) was found in the treatment of NSKE followed by NLE (1:37.20). Through, the spinosad and emamectin benzoate showed higher

Table 2. Effect of various eco-friendly insecticides on pod borer incidence, yield of Indian bean and their economics

Treatments	Number of larva/ plant	Pod damage (%)	Yield (kg/ha)	Gross income (₹/ha)	Quantity of insecticides required for two sprays (L or kg/ha)	Cost of plant protection including labour charge (₹/ha)	Gross realization (₹/ha)	Net realization over control (₹/ha)	ICBR
Beauveria bassiana (2x10^8 cfu/g) @ 1.5 kg/ha	1.16^{cd} (0.84)	36.93^{de} (36.10)	2144^b	25728	1.5	700	25028	10640	1:15.20
Lecanicillium lecanii (2x10^8 cfu/g) @ 1.5 kg/ha	1.20^d (0.93)	38.78^f (39.23)	2119^b	25428	1.5	700	24728	10340	1:14.77
Metarhizium anisopliae (2x10^8 cfu/g) @ 1.5 kg/ha	1.17^{cd} (0.86)	38.30^{df} (38.41)	2263^b	27156	1.5	700	26456	12068	1:17.24
Nomurea rileyi (2x10^8 cfu/g) @ 1.5 kg/ha	1.13^{cd} (0.77)	36.21^{cd} (34.90)	2332^c	27984	1.5	700	27284	12896	1:18.42
Neem seed kernel extract @ 5 %	1.00^b (0.50)	33.56^{ab} (30.56)	3174^e	38088	25.00	525	37563	23175	1:44.14
Neem leaf extract @ 10 %	1.11^{cd} (0.73)	36.25^{cd} (34.96)	2791^d	33492	50.00	500	32992	18604	1:37.20
Neem oil @ 0.5 %	1.09^{bc} (0.68)	34.93^{bc} (32.78)	2884^d	34608	2.55	1420	33188	18800	1:13.23
Spinosad 45 SC (0.015 %)	0.85^a (0.22)	32.68^a (29.15)	3326^f	39912	0.15	1600	38312	23924	1:14.95
Emamectin benzoate 5 SG (0.0025 %)	0.83^a (0.19)	32.50^a (28.87)	3477^g	41724	0.25	2180	39544	25156	1:11.30
Control (water spray)	1.37^e (1.37)	42.66^g (45.92)	1199^a	14388	-	-	14388	-	-
S.Em. ±	0.03	0.51	50.12	-	-	-	-	-	-
C.D. at 5%	0.09	1.44	148.92	-	-	-	-	-	-
C.V. (%)	9.90	5.20	10.13	-	-	-	-	-	-

*Figures are $\sqrt{x+0.5}$ and ** are arc sin transformed values, whereas figures in parentheses are retransformed values.
Treatment means with letter(s) in common are not significant by DMRT at 5 % level of significance
Indian bean pods: ₹ 12/kg Labour charge: ₹ 100/day

(₹ 23924 to 25156/ha) net realization over control, they exhibited relatively poor (1 :11.30 to 1 : 14.95) economic return.

The results concluded that among the different ecofriendly insecticides evaluated, the spray application of neem seed kernel extract (5%) and neem leaves extract (10%) found effective against sucking pests, whereas emamectin benzoate (0.015%) and spinosad (0.0025%) proved to be effective against pod borer infesting Indian bean.

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