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Field efficacy of bio-rational insecticides against major pestiferous insects of cabbage

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ABSTRACT

The major pestiferous insects during both crop seasons included aphids and diamond back moth; while, flea beetles and painted bug attained pest status during 2015-16; besides, tobacco caterpillar was noticed during 2016-17. Maximum reduction in aphid population (45.81 and 54.07%, respectively, at 1 and 3 DAS) was recorded for *A. indica* oil followed by Spinosad 45%SC; same schedule had maximum reduction of flea beetle population 1-DAS (50.03%); while, 3 and 7 days after spray Spinosad 45%SC followed by Spinosad 45%SC gave significantly higher reduction (75.21 and 64.62%, respectively). Maximum reduction of painted bug population (68.37% at 3DAS) was due to *A. incida* oil followed by SI-NPV. Treatment schedule of Spinosad 45%SC followed by Spinosad 45%SC was most effective against DBM during both crop seasons with significantly lowest pooled larval population per plant being 0.82 and 1.0, 3 and 7 days after first spray; likewise, 1.62, 0.92, and 0.90, 1, 3 and 7 days after second spray. Similarly, against tobacco caterpillar, treatment schedule Spinosad 45%SC followed by Spinosad 45%SC was most effective at 3 DAS (0.71 larvae/plant); while, schedules *A. indica* oil followed by Spinosad 45%SC and *A. indica* oil followed by SI-NPV were equally effective 7 DAS during crop season 2016-17 (0.90 larvae/plant).

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Introduction

Cabbage [*Brassica oleracea* var. *capitata* (Linn.): Cruciferae] is one among the abundantly consumed vegetables all over the world. It is cultivated extensively in the tropical and temperate regions of the world including India and has appreciable nutritional and economic value. Cabbage is used as boiled vegetable, in salad, curries and pickles. The total estimated area under cabbage cultivation in India is 399 thousand hectares with an annual production of 9049 thousand tonnes (NHB data base 2016-17). Insect pests are a serious menace in the profitable cultivation of cabbage; the more important being: tobacco caterpillar, *Spodoptera litura* (Fab.); diamond back moth, *Plutella xylostella* L.; cabbage semilooper, *Trichoplusia ni* (Hubner); painted bug, *Bagrada hilaris* (Burmeister); cabbage butterfly, *Pieris brassicae* L.; flea beetles, *Phyllotreta cruciferae* Goeze; aphids, *Lipaphis erysimi* (Kalt.); and the mustard saw fly, *Athalia lugens proxima* (Klug.) (Ayyar and Ramakrishna 1963; Lall 1964). These pests can cause damage to an extent of 80–100 per cent in the nurseries under favourable conditions (Chari et al. 1994) and 10–25 percent to the field crop (Rao and Sitaramaiah 2001). The pest losses due to insect infestation or merely their presence affect the quality and market value of the vegetables very adversely, which are more important than the yield loss. In India, insect pests alone cause field loss to about 15–20% which approximately amounts to Rs.150 crores, but in case of outbreaks, the losses increase up to 50–90%.

Control of insect pests by chemicals can be spectacular but it has its limitations such as high capital investment, non-remunerative, short term measures and also the ill effects of a chemical pesticides on human health and the environment; development of resistance in pests to pesticides and higher levels of pesticide residue in food items; hence there is crying need to develop suitable alternative to chemical pesticides for use in pest control. Use of pest avoidance tactics, enhancement of biological pest suppression and adoption of other nonchemical methods of pest management would certainly be able to improve our capabilities in solving much of the pest problems. So alternative strategies include the investigation for new type of insecticide, and the re-evaluation and use of traditional and these botanical pesticides, which are eco-friendly as well as economic to use. Annual growth rate in the consumption of pesticides was 9.5 percent in the last decade and more than 50 percent of the pesticides are common. Plant

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products for the control of insect pests have been used since ancient times with encouraging reports on the use of certain plant products as insecticides. Pesticides of plant origin have been explored extensively as an alternative to chemicals, as they are effective against target pest, safe to man and are easily biodegradable. Various botanicals were found to be effective against different pests, especially insects and among them efficacy of *neem* has been proven and documented (Schmutterer 1990; Strak and Waiter 1996); however, higher concentrations can cause burning of plant leaves; besides, natural enemies such as *Cotesia* species can be negatively affected by *neem* applications (Loke et al. 1992). Neem, *Azadirachta India* is one such perennial tree, which grows in India, its potential was first demonstrated by Pradhan et al. (1962), which actually saved the crops against pests, Neem is already stated having diverse biological effects on insects and about 200 insect species have so far been reported to respond to neem treatments. They contain terpenoids that are phago-deterrent, growth inhibitors and ovipositor suppressant (Sharma et al. 1984).

Material and methods

Site and location of the experiments

The investigations were carried out at the Instructional Farm of Rajasthan College of Agriculture, MPUAT, Udaipur for two successive crop seasons, *rabi* 2015-16 and 2016-17. Geographically, Udaipur is located at 23.4°N Longitude and 75°E Latitude at an elevation of 579.5 MSL in the state of Rajasthan.

Climate and weather conditions of the location

The climate of the region is subtropical, characterized by mild winters and hot summers that provide a safe and long growing season for most crops. The average annual rainfall of this tract ranges from 650 to 750 mm, most of which is received during July to September with occasional rain during the winter season. During summer, the temperature may shoot up to 45.5 °C, while in winters it may fall to as low as 4.5 °C. During the years 2015 and 2016 the annual precipitation was 563.00 and 660.90 mm.

Preparation of land and manuring

The experimental field was prepared by ploughing once followed by cross harrowing and planking. Required quantity of FYM and the synthetic fertilizers were applied as per the recommendations for Zone IV (a). The crop was in the field from December to March during both the years.

Preparation of nursery for seedling of cabbage

Cabbage (Goldn Acre) was planted in well prepared raised nursery beds during both years (4rd week of November, 2015 and 3rd week of November 2016, respectively). All recommended horticultural operations were followed while raising the seedlings.

Experimental details

Recommended bio-pesticides were evaluated for their efficacy against the major insect pests of cabbage during the two successive crop seasons of *rabi* 2015-16 and 2016-17. The experiments were conducted at the Instructional Farm of Rajasthan College of Agriculture, Udaipur. The trials were laid out with 5 treatments and 4 replications in uniformly sized plots measuring 4.5 m × 4.5 m in Randomized Block Design and in all there were 20 plots. The row to row and plant to plant spacing for cabbage were 45 and 45 cm, respectively. Sowing of the cabbage variety Golden Acre was done in the *rabi* season during the two successive years 2015 and 2016.

Treatment schedules

1. *Azadirachta indica* oil (1%) followed by Spinosad (0.32 ml/l)
2. Indoxacarb 14.5 SC (0.60 ml/l) two applications
3. *Azadirachta indica* oil (1%) followed by SL-NPV (250 LE/ha)
4. Spinosad 45 SC(0.32 ml/l) followed by Spinosad 45 SC (0.32 ml/l)
5. Untreated control

Observations

The population of major insect pests of cabbage and their natural enemies were recorded one day before of spray and 1, 3 and 7 days after the application of bio-pesticides. The first spray was given after ten days of transplanting and subsequent spray was done after fifteen days of first spraying.

- Estimation of aphid population was done by numerical count method on five randomly selected tagged plants (Lal 1998). Initially, the whole plant was examined and the total number of aphids per plant was counted visually with the help of magnifying lens. In the advanced stage of plants, the observations were recorded from outer leaves only.
- Population estimation of tobacco caterpillar, diamond back moth and flea beetles were made on five randomly selected tagged plants in each replicate by visual counting method.

Table 1. Bio-rational insecticide efficacy on insect pests of cabbage over crop season, *Rabi* 2015-16.

	Mean reduction (%) after I-spray											
	Aphids				Flea beetles				Painted bugs			
Treatment schedule	PTP	1 DAS	3 DAS	7 DAS	PTP	1 DAS	3 DAS	7 DAS	PTP	1 DAS	3 DAS	7 DAS
Control	112.85	–	–	–	52.00	–	–	–	6.00	–	–	–
Neem oil followed by Spinosad	127.75	39.59^{b} (40.61)	46.22^{c} (52.13)	42.65 (45.91)	40.75	45.02^{c} (50.03)	52.55^{a} (63.02)	46.05^{a} (51.83)	4.50	36.30 (35.04)	54.03^{b} (65.50)	49.10 (57.13)
Indoxacarb followed by Indoxacarb	120.75	32.93^{a} (29.56)	38.72^{a} (39.13)	39.92 (41.19)	42.00	42.84^{b} (46.24)	53.31^{a} (64.30)	52.16^{b} (62.37)	5.25	33.47 (30.41)	41.23^{a} (43.44)	41.09 (43.20)
Neem oil followed by Sl-NPV	129.15	38.07^{a} (38.02)	45.89^{c} (51.55)	41.63 (44.12)	44.75	42.99^{bc} (46.50)	53.13^{a} (64.00)	46.49^{a} (52.59)	4.25	38.43 (38.63)	55.78^{b} (68.37	47.66 (54.63)
Spinosad followed by Spinosad	158.40	34.96^{b} (32.84)	41.74^{b} (44.33)	39.46 (40.39)	47.75	40.87^{a} (42.82)	60.14^{b} (75.21)	53.50^{b} (64.62)	5.00	34.51 (32.10)	42.10^{a} (44.94)	42.78 (46.13)
S. Em. ±	11.05	0.643	0.545	0.825	4.63	0.395	0.554	0.769	0.73	1.607	1.831	2.231
CD (p = 5%)	NS	2.057	1.744	NS	NS	1.263	1.773	2.460	NS	NS	5.859	NS

Note: 1) Figures in the parentheses are retransformed per cent values.
2) PTP- pre-treatment population (Mean / plant).
3) DAS - Days after spray.
4) Values superscripted by the same letter are statistically at par.

The population data (for aphids, flea beetles and painted bugs) were subjected to the Henderson and Tilton (1955) method of estimating population reduction after the treatments.

$$\text{PopulationReduction}(\%) = 100\left(1 - \frac{\text{Ta.Cb}}{\text{Tb.Ca}}\right)$$

where Ta = numbers of insect-pests/natural enemies in the treatments after application, Tb = numbers of insect-pests/natural enemies in the treatments before application, Ca = numbers of insect-pests/natural enemies in the control after application, Cb = numbers of insect-pests/natural enemies in the control before application.

The efficacy of bio-rational insecticides against diamond back moth was observed on the basis of larval count before and after spraying.

The first spray used to evaluate against all the major insect pests and second spray used for diamond back moth and tobacco caterpillar.

Results and discussion

Aphids

All the bio-rational insecticide treatments were significantly superior over control (water spray) 1 and 3 days after spray, but the treatments did not differ significantly 7 days after spray. The pre-treatment aphid population did not vary significantly among the treatments and ranged from 112.85 to 158.40 and 16.40 to 20.60 aphids/plant during *rabi* 2015-16 (depicted in Table 1) and 2016-17 (depicted in Table 2), respectively. One-day after spray, the maximum reduction in aphid population was recorded in the treatment of *neem* oil followed by spinosad (up to 40.61% in 2015-16 and 51.05% in 2016-17), which was at par with *neem* oil followed by Sl-NPV (38.02% in 2015-16 and 48.19% in 2016-17). Minimum reduction was in indoxacarb followed by indoxacarb (29.56% in 2015-16 and 28.30% in 2016-17). Similarly, 3 days after spray, the maximum reduction in population of aphids was recorded in treatment *neem* oil followed by spinosad (52.13% in 2015-16 and 56.02% in 2016-17), which was at par with *neem* oil followed by Sl-NPV (51.55% in 2015-16 and 54.40% in 2016-17); whereas, minimum reduction was found in indoxacarb followed by indoxacarb (39.13% in 2015-16 39.19% in 2016-17), which was at par with spinosad followed by spinosad (43.32% in 2016-17).

Flea beetles

During the experimental period 2016-17, flea beetle appeared late and could be evaluated only during the experimental period 2015-16. The flea beetle pre-treatment population did not show any significant difference among the treatments and the mean population ranged from 40.75 to 52.00 flea beetles/plant (Table 1). All the treatment schedules were significantly better than control at 1, 3 and 7 days after spray. Significantly higher reduction in the population of flea beetle (50.03%) was recorded in the treatment schedule *neem* oil followed by spinosad; whereas, the minimum reduction (42.82%) was recorded for the treatment schedule spinosad followed by spinosad after first spray. Three days after spray significantly maximum reduction in aphid population (75.21%) was recorded in the treatment schedule spinosad followed by spinosad; whereas, minimum reduction was in *neem* oil followed by spinosad (63.02%), which was at par with *neem* oil followed by Sl-NPV (64.00%) and indoxacarb followed by indoxacarb (64.30%). After 7 days of spray, significantly maximum reduction in the population of flea beetle was recorded in the treatment spinosad followed by spinosad (64.62%), though it was at par with *neem* oil followed by Sl-NPV (62.37%); while, lowest reduction was in indoxacarb followed by

Table 2. Bio-rational insecticide efficacy on aphid of cabbage over crop season, *Rabi* 2016-17.

Treatment schedule	PTP	Mean reduction (%) after I-spray 1 DAS	3 DAS	7 DAS
Control	16.40	–	–	–
Neem oil followed by Spinosad	18.05	45.60[c] (51.05)	48.45[b] (56.02)	40.77 (42.64)
Indoxacarb followed by Indoxacarb	17.50	32.14[a] (28.30)	38.76[a] (39.19)	36.33 (35.10)
Neem oil followed by Sl-NPV	16.60	43.97[c] (48.19)	47.52[b] (54.40)	41.36 (43.66)
Spinosad followed by Spinosad	20.60	35.49[b] (33.71)	41.16[a] (43.32)	38.11 (38.09)
S. Em. ±	1.72	1.022	1.159	1.334
CD (p = 5%)	NS	3.270	3.707	NS

Note: 1) Figures in the parentheses are retransformed per cent values.
2) PTP- pre treatment population (Mean/ plant).
3) DAS - Days after spray.
4) Values superscripted by the same letter are statistically at par.

indoxacarb (51.83%) that was at par with *neem* oil followed by Sl-NPV (52.59%).

Painted bug

During the experimental period 2016-17, painted appeared late and could be evaluated only during the experimental period 2015-16. The pre-treatment population counts of painted bugs did not show significant variation among the treatments and ranged from 4.25 to 6.00 bugs/plant as depicted in Table 1. The bio-rational insecticides were significantly effective over control only at 3 days after spray and the maximum reduction in the population of painted bug was recorded in the treatment schedule of *neem* oil followed by Sl-NPV (68.37%), which was at par with the schedule *neem* oil followed by spinosad (65.50%). The minimum reduction in population was recorded in the treatment schedule of indoxacarb followed by indoxacarb (43.44%) that was at par with spinosad followed by spinosad (44.94%).

Diamond back moth

The pre-treatment population of diamond back moth ranged from 2.35 to 4.16 larvae/plant before first spray and 1.00 to 1.67 larvae/plant before second spray in 2015-16 (depicted in Table 3) whereas, 2.95–3.85 larvae/plant before first spray and 4.37–6.95 larvae/plant before second spray in 2016-17 (depicted in Table 4) and both the years it was statistically at par among treatments. The lowest larval population of DBM was recorded in the treatment schedule spinosad followed by spinosad with 0.54, 0.35 and 0.44 larvae/plant at 1, 3 and 7 days first after spray during *rabi* 2015-16, respectively. The response was at par with indoxacarb followed by indoxacarb with 0.74, 0.43 and 0.52 larvae/plant at 1, 3 and 7 days after first spray (*rabi* 2015-16), respectively). Whereas, one day after second spray *rabi* 2015-16, significantly minimum population of DBM (1.78 larvae/plant) was recorded in the treatment schedule of spinosad followed by spinosad. After 3 and 7 days of second spray (*rabi* 2015-16), the minimum population of DBM was recorded in the treatment schedule spinosad followed by spinosad being 0.95 and 0.81 larvae/plant, respectively; however, being at par with the treatment indoxacarb followed by indoxacarb recording 1.00 and 0.98 larvae/plant, respectively. All the treatments were significantly superior over control at 3 and 7 days after first spray during 2016-17. Three days after first spray (2016-17), the minimum larval population of DBM was recorded in treatment spinosad followed by spinosad (1.41 larvae/plant), which was at par with indoxacarb followed by indoxacarb (2.14 larvae/plant). Similarly, seven days after first spray (2016-17), the lowest larval population of DBM was recorded in treatment spinosad followed by spinosad (1.69 larvae/plant). One day after second spray (2016-17), the minimum larval population of DBM was recorded in treatment spinosad followed by spinosad (1.47 larvae/plant), which was at par with indoxacarb followed by indoxacarb (1.87 larvae/plant). 3 and 7 days after second spray during *rabi* 2016-17, the minimum population of diamond back moth was recorded in the treatment spinosad followed by spinosad (0.90 and 0.99 larvae/plant, respectively), which were at par with treatment indoxacarb followed by indoxacarb (0.90 and 1.22 larvae/plant, respectively). Invariably, the maximum population of DBM was in the control.

Tobacco caterpillar

During the experimental period 2016-17 (depicted in Table 5), tobacco caterpillar appeared late and could be evaluated only at the time of second spray application. Three days after spray, significantly minimum population of tobacco caterpillar was recorded in the treatment *neem* oil followed by spinosad and indoxacarb followed by indoxacarb; whereas, 7 days after spray the minimum population was recorded in treatment *neem* oil followed by Sl-NPV.

It has been well established that plant products derived from neem (*Azadirachta indica* A. Juss.) contain biologically active components that may act as toxicant, repellent, antifeedant and growth disrupting substance on insect pests and are considered free from residual problems (Koul et al. 1990; Gujar 1992). Neem oil (1.5 per cent) spray showed 100 percent mortality of aphids (Mani et al. 1990). Neem oil (0.5%) spray on cauliflower showed repellency to *B. brassicae* (Singh and Sharma 1986).

Table 3. Bio-rational insecticidal efficacy on diamond back moth of cabbage over crop season *Rabi* 2015-16.

	Mean larvae per plant							
	I- spray				II- spray			
Treatment schedule	PTP	1 DAS	3 DAS	7 DAS	PTP	1 DAS	3 DAS	7 DAS
Control	2.08 (3.84)	1.43^{b} (1.55)	1.51^{c} (1.77)	1.73^{d} (1.73)	1.29 (1.15)	2.14^{c} (4.07)	2.24^{d} (4.51)	2.16^{d} (4.19)
Neem oil followed by Spinosad	1.69 (2.35)	1.41^{b} (1.48)	1.27^{b} (1.12)	1.42^{c} (1.52)	1.47 (1.67)	1.44^{a} (1.58)	1.09^{a} (0.69)	1.09^{a} (0.69)
Indoxacarb followed by Indoxacarb	1.75 (2.58)	1.12^{a} (0.74)	0.97^{a} (0.43)	1.01^{a} (0.52)	1.22 (1.00)	151^{a} (1.78)	1.22^{b} (1.00)	1.22^{b} (0.98)
Neem oil followed by SI-NPV	2.16 (4.16)	1.42^{b} (1.52)	1.32^{b} (1.24)	1.26^{b} (1.09)	1.42 (1.51)	2.00^{b} (3.50)	1.68^{c} (2.32)	1.58^{c} (1.99)
Spinosad followed by Spinosad	1.89 (3.09)	1.02^{a} (0.54)	0.92^{a} (0.35)	0.97^{a} (0.44)	1.28 (1.15)	1.51^{a} (1.78)	1.20^{b} (0.95)	1.15^{a} (0.81)
S. Em. ±	0.057	0.045	0.050	0.036	0.064	0.026	0.026	0.023
CD (p = 5%)	NS	0.139	0.154	0.117	NS	0.080	0.081	0.071

Note: 1) Figures in the parentheses are retransformed square values.
2) PTP- pre- treatment population (Mean/ plant).
3) DAS - Days after spray
4) Values superscripted by the same letter are statistically at par.

Table 4. Bio-rational insecticides efficacy on diamond back moth of cabbage over crop season *Rabi* 2016-17.

	Mean larvae per plant							
	I-spray				II- spray			
Treatment schedule	PTP	1 DAS	3 DAS	7 DAS	PTP	1 DAS	3 DAS	7 DAS
Control	1.89 (3.07)	1.94) (3.28)	2.52^{c} (5.86)	2.51^{c} (5.78)	2.73 (6.95)	2.64^{d} (6.48)	2.49^{c} (5.69)	2.54^{c} (5.96)
Neem oil followed by Spinosad	2.05 (3.70)	1.87 (3.00)	1.91^{b} (3.14)	2.06^{b} (3.75)	2.44 (5.46)	1.77^{b} (2.64)	1.61^{b} (2.09)	1.79^{b} (2.70)
Indoxacarb followed by Indoxacarb	2.00 (3.51)	1.80 (2.73)	1.63^{ab} (2.14)	1.81^{b} (2.79)	2.21 (4.37)	1.54^{ab} (1.87)	1.18^{a} (0.90)	1.31^{a} (1.22)
Neem oil followed by SI-NPV	1.86 (2.95)	1.89 (3.06)	1.88^{b} (3.03)	2.07^{b} (3.79)	2.21 (4.38)	2.05^{c} (3.71)	1.56^{b} (1.95)	1.59^{b} (2.04)
Spinosad followed by Spinosad	2.09 (3.85)	1.48 (1.68)	1.38^{a} (1.41)	1.48^{a} (1.69)	2.26 (4.59)	1.40^{a} (1.47)	1.18^{a} (0.90)	1.22^{a} (0.99)
S. Em. ±	0.04	0.90	0.10	0.10	0.07	0.082	0.066	0.069
CD (p = 5%)	NS	NS	0.32	0.304	NS	0.252	0.204	0.213

Note: 1) Figures in the parentheses are retransformed square values.
2) PTP- pre treatment population (Mean/ plant).
3) DAS - Days after spray.
4) Values superscripted by the same letter are statistically at par.

Table 5. Bio-rational insecticides efficacy against tobacco caterpillar on cabbage over crop season *Rabi* 2016-17.

	Mean larvae per plant			
Treatment schedule	PTP	1 DAS	3 DAS	7 DAS
Control	1.72 (2.45)	1.90 (3.11)	1.97^{c} (3.38)	1.72^{c} (2.45)
Neem oil followed by Spinosad	1.92 (3.20)	1.64 (2.21)	1.22^{a} (1.00)	1.18^{a} (0.90)
Indoxacarb followed by Indoxacarb	1.75 (2.55)	1.47 (1.67)	1.34^{a} (1.31)	1.37^{b} (1.38)
Neem oil followed by SI-NPV	1.80 (2.75)	1.63 (2.17)	1.45^{b} (1.61)	1.18^{a} (0.89)
Spinosad followed by Spinosad	1.85 (2.91)	1.37 (1.38)	1.10^{a} (0.71)	1.24^{a} (1.05)
S. Em. ±	0.04	0.08	0.09	0.05
CD (p = 5%)	NS	NS	0.28	0.17

Note: 1) Figures in the parentheses are retransformed square values.
2) PTP- pre-treatment population (Mean/ plant).
3) DAS - Days after spray.
4) Values superscripted by the same letter are statistically at par.

Chandramohan and Nanjan (1992) showed that a neem oil product called "Biosol" (0.4%) was 3–4 times more effective against *Plutella xylostella* in comparison to organic garlic spray and control. Klemm and Schmutterer (1993) combat this pest by neem seed kernel water extract at 25 gm and 30 gm seed kernels per lit of water on the pest and its natural enemies. In field, the numbers of larvae were significantly reduced by the application of *neem* to 4.98 and 5.92 larvae per plant at the end of experiment compared to control 18.57 larvae per plant. Development of *P. xylostella* pupae was generally low and adult zero on neem treated plants. Bio-pesticides together with synthetic pesticides have been compared for their efficacy against major insect pests of cabbage/cole crops. Kamala et al. (2003) reported that Abamectin, NSKE and Spinosad gave highest number of marketable cabbage heads as well as yield, while Dipel and Neemazal were on par but superior to neem oil soap, pongania oil soap and control. *Bt* product Dipel, Neemazal, neem oil soap and pongania oil soap failed to give satisfactory results. Patil et al. (2003) evaluated the efficacy of plant extracts and new insecticides against DBM on cabbage. Treatment of Azadirachtin, Carina (profenofos), Rocket (profenophos + cypermethrin) showed 100 percent efficacy in the fourth spray at seven days after spraying. Shankaara et al. (2003) evaluated the bio-efficacy of commercial neem formulations *viz*., Soluneem (0.15%) Econeem plus (0.3%) Vijayneem (0.3%) Neemark (0.6%), two plants extract both at 10%, indoxacarb (0.0075%) fipronil (0.01%) and a standard check, NSKE (4%) against diamond back moth on cabbage. The results showed that indoxacarb and fipronil were most effective. NSKE (4%) was slow in its action; it was highly effective and was on par with two new insecticides molecules in suppressing the DBM by the end of third spray. Among CNF-s, Soluneem and Econeem plus were found effective, while Neemark and Vijayneem were ineffective. Stanley et al. (2006) reported that emamectin and spinosad were effective at 0.40 ppm and 125 ppm for *S. litura*. Topagi (2010) reported that spinosad 45 SC (0.015%) was very effective against *S. litura* with 51 percent mean reduction in larval population over untreated check. Ali et al. (2011) reported the treatments *Sl*-NPV at 250 LE/ha + neem seed kernel extract (NSKE) at 5.00 percent and *Sl*-NPV + neem oil at 2.00 percent to be most effective in reducing the population of the pest 62.60 percent and 61.20 percent, respectively and it recorded the lowest head damage (14.30% and 14.70%) and the highest head yield (226.40 and 224.50 q/ha, respectively). Bhutia et al. (2012) reported that the larvae of *S. litura* (F.) were susceptible to NPV and the virulence of Sl-NPV proved most effective at 1×10^{-6} POB's/ml with LT_{50} at 5.09 d.

Conclusion

The major pestiferous insects during both crop seasons included the aphids and diamond back moth; while, flea beetles and the painted bug attained pest status during 2015-16; besides, the tobacco caterpillar was noticed during 2016-17. For the management of sucking insect pests viz., aphids, painted bug and defoliator like flea beetle; *A. indica* oil at the rate of 1 percent was effective whereas, tobacco caterpillar and diamond back moth were managed by use of Spinosad 45 SC at the rate of 0.33 ml per liter of water.

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