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Comparative efficacy of selected insecticides and aqueous neem seed kernel extract against *Pieris brassicae* infesting cauliflower in dry temperate zone of North Western Himalaya

SANJAY KUMAR SHARMA[1] and P C SHARMA[2]

CSK HPKV, Highland Agricultural Research and Extension Centre, Kukumseri (Lahaul and Spiti), Himachal Pradesh 175142

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Cauliflower is an important vegetable crop grown by the farmers of India. Its total acreage in India is about 0.35 million hectare with a production of nearly 6.5 million tonnes (Ahuja *et al.* 2012). The cruciferous vegetables in Himachal Pradesh are grown over an area of 7515 ha, of which 3002 ha is under cauliflower alone (Anonymous 2011). In the Lahaul valley of this hill state, until recently, these crucifers were mainly grown for domestic consumption. However, during the last few years their cultivation has picked up tremendously and many farmers have started growing these vegetables on commercial scale. The increased acreage under crucifer vegetables is helping to bring in a semblance of much needed diversification in the monoculture of garden pea and potato in the Lahaul valley. Growing crucifers in this dry temperate zone seems to be quite remunerative proposition as peas and potatoes are being phased out gradually in the menace of diseases. However, rampant pest infestations that attack the crucifers beginning with the seedling to harvesting are most important limiting factor in their successful cultivation. Amongst these, *Pieris brassicae* (L.) is the major pest that attacks the crop foliage when the plants are firmly established in the field (Bhatia and Verma 1993, Anonymous 2008). Hordes of adult *P. brassicae* can be seen flying in and around these crops. This pest is potentially capable of completely devastating the crops if timely remedial measures are not taken. The larvae of *P. brassicae* feed gregariously and voraciously on the crucifer foliage. Keeping in view the importance of cultivating these crops to diversify the agriculture scenario in the valley and to instil confidence in the farmers for successful cultivation of these crops, five insecticides and aqueous neem seed kernel extract (NSKE) were evaluated for its effective management in cauliflower.

[1] SMS Entomology (e mail: sanjayhpau@yahoo.com), CSK HPKV, Krishi Vigyan Kendra, Lahaul and Spiti, Kukumseri, Himachal Pradesh 175 142; [2] Assistant Entomologist (e mail: pcsharma@hillagric.ac.in), Department of Entomology, College of Agriculture, CSK HPKV Palampur, Himachal Pradesh 176 062

Experiments were conducted at the Research Farm of Highland Agricultural Research and Extension Centre, Kukumseri (2772 m MSL) in randomized block design (RBD) with three replications during *kharif* 2008 and 2009. Each plot measured 3.0 × 2.25 m^2 and the two consecutive plots were separated by distance of 75 cm so as to reduce the remotest possibility of insecticidal drift. The cauliflower seedlings (variety Pusa Snow Ball K 1) were transplanted in the first week of May at 60 and 45 cm between plant to plant and row to row, respectively. Each plot accommodated 25 plants. The recommended packages of practices were followed in raising the crop except plant protection measures against the insect pests. Even no insecticide was applied against cutworms that damaged the crop at seedling stage. The seedlings damaged by the cutworms were replaced so as to maintain the full plant stand. The cutworms were killed after manually removing them by digging the basins around the affected seedlings. The cabbage aphid, *Brevicoryne brassicae* L. is another major pest of crucifers in this region. However, *P. brassicae* precedes in appearance to *B. brassicae*. Therefore, no special measures were warranted to control *B. brassicae* in the experimental crop.

The initial observations of *P. brassicae* adults flying around indicated the onset of pest activity. Thereafter, crop in the experimental field was regularly monitored for the appearance of egg masses of *P. brassicae*. The treatment sprays were initiated when around 20 to 25 per cent plant infestation was observed. The experimental site normally experienced high velocity winds in the afternoon. Therefore, the sprays were done in the morning hours to avoid insecticidal drift. The treatments included five insecticides, viz. lambda cyhalothrin 5 EC [Bravo5000®] (0.0025%), profenofos 50 EC [Profenofos®] (0.05%), triazophos 40 EC [Hostathion®] (0.04%), imidacloprid 17.8 SL [Maharaja®] (0.0178%), dichlorvos 76 EC [Nuvan®] (0.018%) and NSKE (5.0 ml/L).

The NSKE was prepared by soaking 50 g broken neem seed kernels in one litre water for 24 h. The sprays of

insecticide and NSKE were repeated after 14 days. The sprays were done using a knapsack sprayer fitted with flat fan nozzle and spray volume of 750 litres per hectare was used.

The data were recorded on number of eggs and larvae of *P. brassicae* per plant, number of infested plants per plot and yield of marketable curds. Five plants per plot, excluding the plants in the border rows, were selected at random for calculating the mean number of eggs and larvae per plant. For working out per cent plant infestation, all plants in a plot were observed for the presence of egg masses and larvae of *P. brassicae* because the effect of insecticide drift was checked by keeping sufficient distance between adjacent plots. A plant was considered as infested even if a single larva was spotted on it. The eggs in egg masses were visually estimated. The estimations were based on the actual counting of eggs in several egg masses by using a magnifying lens. Data on the marketable yield of cauliflower curds obtained from each plot were recorded at each harvest. The yields of respective plots were summed up after final harvesting to get the total yield for each plot. The replication-wise data on the pest population and per cent plant infestation were averaged separately for the two years. The averaged data on per cent plant infestation were analysed after arc sine transformation and that on pest population and yield were analysed after square root transformations using CPCS1 software. In order to know the most effective treatment, per cent change, i.e. increase (+) or decrease (–) in *P. brassicae* population and plant infestation over pre-treatment and per cent increase in marketable yield of curds over control were worked out as below:

- Per cent change (+ or –) in pest population at 14 DAS_1/ 14 DAS_2 = $[(P_2 - P_1) / P_1] \times 100$; where P_1: Pest population (number of eggs and larvae/ plant) at pre-treatment and P_2: Pest population (number of eggs and larvae/ plant) at 14 DAS_1/14 DAS_2 (Days after first/ second sprays).
- Per cent change (+ or –) in plant infestation at 14 DAS_1/14 DAS_2 = $[(PI_b - PI_a) / PI_a] \times 100$; where PI_a: % plant infestation at pre-treatment and PI_b: % plant infestation at 14 DAS_1/14 DAS_2.
- Per cent increase (+) in marketable yield of cauliflower curds over control = [(Yield in sprayed plot –Yield in control)/ Yield in control] × 100

The per cent changes in pest population and plant infestation were computed over pre-treatment instead of control because pre- and post-application data from the same plots would truly reflect the efficacy of sprayed insecticides.

The benefit cost (BC) ratios were calculated by taking into account all the expenditures incurred for raising the crop including field preparation, seedlings, manures, fertilizers, insecticides, labour and implements depreciation. The summation of all these expenditures gave the total working capital (TWC). Then, interest (10% per annum) on the total working capital was calculated for two months (half period of the crop) and it was added to the total working capital to get total variable cost (TVC). The gross returns (GR) were worked out by multiplying the quantity of marketable curds produced with prevailing wholesale market price. The benefit cost ratios were calculated as under:

BC ratio = Net Returns/Total Variable Cost; where

Net Returns = Gross Returns – Total Variable Cost

Lambda cyhalothrin and dichlorvos were statistically non significant and superior to other insecticides in reducing the *P. brassicae* population in 2008. The plots sprayed with these two insecticides reduced the population from 30 and 25 eggs plus larvae per plant at pre-treatment to 6.67 and 4.67 eggs plus larvae per plant, 14 days after first spray (DAS_1), respectively in this year. This amounted to 77.23 and 80.99 per cent reduction in *P. brassicae* population over pre-treatment after the same duration (Table 1). On the other hand, in 2009, all the insecticides were statistically non-significant in reducing the *P. brassicae* population. The highest reduction in population was recorded for lambda cyhalothrin (87.29%) at 14 DAS_1. However, at 14 days after second spray (DAS_2), all the insecticides in both the years were statistically non-significant and resulted in more than 95 per cent reduction in *P. brassicae* population over pre-treatment (Table 1).

On the other hand, all the insecticides were statistically non-significant in reducing plant infestation at 14 DAS_1 and 14 DAS_2 during both the years. However, the highest reduction in plant infestation was recorded for dichlorvos (83.70%) in 2008 and triazophos (83.51%) in 2009 at 14 DAS_1. At 14 DAS_2, all the insecticides reduced plant infestation by more than 93 per cent over pre-treatment in both the years (Table 2). NSKE was least effective in reducing *P. brassicae* population and plant infestation in both the years (Tables 1 and 2).

In 2008, the highest yield of marketable curds was obtained from plots sprayed with dichlorvos (0.018%). This yield was statistically non-significant to that obtained from lambda cyhalothrin (0.0025%) sprayed plots and superior to the yields realized from other insecticide treatments in this same year. The curd yield from dichlorvos (16.87 tonnes/ha) and lambda cyhalothrin (15.53 tonnes/ ha) sprayed plots was 115.45 and 98.34 per cent more than control, respectively (Table 3). However, in 2009, all the insecticides recorded statistically equivalent yields of marketable curds which were superior to NSKE sprayed and control plots. Nevertheless, the highest yield of marketable curds was obtained from lambda cyhalothrin sprayed plots (15.75 tonnes/ha) which was 159.05 per cent higher than control (Table 3).

Although all the insecticides returned BC ratios of more than two, the highest ratio was recorded for dichlorvos (2.51) followed by lambda cyhalothrin (2.40). NSKE sprayed plots gave BC ratio of 0.84 which was slightly better than control (0.51).

The per cent increase in yield of marketable curds over the control was higher in 2009 (Table 3). This may be attributed to comparatively low curd yield recorded in the

Table 1 Effect of insecticides and aqueous neem seed kernel extract sprays on population of *Pieris brassicae* infesting cauliflower

Treatment (Concentration)	2008					2009				
	Population[1] (No. of eggs + larvae/ plant)			Per cent change in population over PTM[2]		Population[1] (No. of eggs + larvae/ plant)			Per cent change in population over PTM[2]	
	PTM[3]	14 DAS_1[4]	14 DAS_2[4]	14 DAS_1	14 DAS_2	PTM	14 DAS_1	14 DAS_2	14 DAS_1	14 DAS_2
Lambda cyhalothrin (0.0025%)	30.00 (5.56)	6.67 (2.76)[a]	0.70 (1.26)[a]	–77.23	–97.66	39.33 (6.27)	5.00 (2.43)[a]	0.42 (1.18)[a]	–87.29	–98.92
Profenofos (0.05%)	28.00 (5.38)	19.33 (4.50)[b]	0.37 (1.15)[a]	–31.13	–98.76	49.00 (6.81)	13.93 (3.74)[a]	1.13 (1.46)[a]	–71.57	–97.33
Triazophos (0.04%)	30.67 (5.58)	16.67 (4.20)[b]	0.37 (1.15)[a]	–42.76	–98.51	37.40 (6.14)	9.33 (3.10)[a]	1.20 (1.48)[a]	–74.46	–96.57
Imidacloprid (0.0178%)	29.00 (5.47)	14.67 (3.92)[b]	0.05 (1.02)[a]	–48.64	–99.83	29.33 (5.47)	8.93 (3.10)[a]	1.27 (1.44)[a]	–65.33	–95.26
Dichlorvos (0.018%)	25.00 (5.09)	4.67 (2.38)[a]	0.05 (1.02)[a]	–80.99	–99.78	37.33 (6.18)	7.67 (2.94)[a]	0.80 (1.31)[a]	–79.37	–98.09
NSKE (5.0 ml/L)	25.67 (5.16)	31.33 (5.69)[c]	14.33 (3.91)[b]	+22.40	–44.26	19.47 (4.51)	36.53 (6.11)[b]	20.60 (4.64)[b]	+88.59	–32.38
Control	21.33 (4.71)	34.33 (5.91)[c]	14.33 (3.89)[b]	+60.37	–46.68	42.27 (6.55)	80.00 (8.97)[c]	30.00 (5.50)[c]	+88.05	–29.20
CD (P=0.05)	(NS)	(0.73)	(0.53)			(NS)	(1.39)	(0.71)		

[1]Figures in the parentheses are square root transformed values; [2]Positive (+) and negative (–) signs denote increase and decrease in pest population, respectively; [3]Pre-treatment; [4]Days after first/second spray.

Table 2 Effect of insecticides and aqueous neem seed kernel extract sprays on plant infestation by *Pieris brassicae* infesting cauliflower

Treatment (Concentration)	2008					2009				
	Plant infestation[1] (%)			Change in plant infestation over PTM[2] (%)		Plant infestation[1] (%)			Change in plant infestation over PTM[2] (%)	
	PTM[3]	14 DAS_1[4]	14 DAS_2[4]	14 DAS_1	14 DAS_2	PTM	14 DAS_1	14 DAS_2	14 DAS_1	14 DAS_2
Lambda cyhalothrin (0.0025%)	33.04 (33.94)	8.31 (16.62)[a]	1.71 (6.53)[a]	–74.87	–94.70	36.42 (37.02)	7.62 (15.22)[a]	1.19 (4.78)[a]	–79.92	–97.36
Profenofos (0.05%)	38.18 (38.08)	10.63 (18.49)[a]	0.85 (3.85)[a]	–58.60	–98.05	27.65 (31.19)	6.69 (14.54)[a]	0.85 (3.85)[a]	–76.67	–97.74
Triazophos (0.04%)	33.41 (35.22)	6.67 (14.56)[a]	1.01 (4.14)[a]	–77.84	–97.32	37.20 (37.27)	5.95 (13.70)[a]	1.55 (4.96)[a]	–83.51	–97.31
Imidacloprid (0.0178%)	28.12 (31.98)	8.68 (16.84)[a]	0.83 (3.81)[a]	–69.13	–96.56	28.43 (32.15)	7.89 (16.20)[a]	0.24 (2.37)[a]	–71.77	–98.98
Dichlorvos (0.018%)	31.76 (34.16)	5.53 (13.15)[a]	1.62 (5.05)[a]	–83.70	–95.96	32.68 (34.78)	6.45 (13.78)[a]	2.26 (5.84)[a]	–80.12	–93.22
NSKE (5.0 ml/L)	40.12 (39.24)	52.92 (46.66)[b]	17.90 (24.92)[b]	+34.05	–55.16	39.65 (38.92)	46.62 (43.00)[b]	25.02 (29.99)[b]	+18.24	–33.70
Control	36.89 (37.35)	50.45 (45.25)[b]	19.92 (26.44)[b]	+36.78	–44.42	33.71 (35.28)	49.31 (44.59)[b]	24.16 (29.39)[b]	+53.82	–39.24
CD (P=0.05)	(NS)	(7.65)	(7.09)			(NS)	(9.81)	(8.87)		

[1]Figures in the parentheses are arc sine transformed values; [2]Positive (+) and negative (–) signs denote increase and decrease in plant infestation, respectively; [3]Pre-treatment; [4]Days after first/second spray.

control plots as the crop suffered heavily from rapid increase in pest population (88.05%) and plant infestation (53.82%) as compared to 60.37 and 36.78 per cent, respectively in 2008 (Tables 1 and 2).

The results of present studies are corroborated by Sharma and Sood (2005) who found that the modules comprising of two sprays of lambda cyhalothrin were very effective in reducing larval population of *P. brassicae* and Halimie *et al.* (1992) who reported 96.14 per cent reduction in *P. brassicae* population by lambda cyhalothrin. Present findings are also in agreement with Singh *et al.* (2003) who reported profenofos (0.05%) and imidacloprid (0.007%) as significantly more effective than neem products in causing mortality of third instar larvae of *P. brassicae* after 72 h of spraying in laboratory studies. However, contrary to the present results, Dhaliwal *et al.* (1997) reported 80 and

Table 3 Marketable yield of cauliflower curds and benefit cost ratios.

Treatment (Concentration)	Marketable yield of curds (tonnes/ha)[1]		Mean yield (tonnes/ha)	Increase in yield over control (%)		Benefit cost ratio[2]
	2008	2009		2008	2009	
Lambda cyhalothrin (0.0025%)	15.53 (4.07)^{ab}	15.75 (4.09)^{a}	15.64	98.34	159.05	2.40
Profenofos (0.05%)	13.63 (3.82)^{c}	14.97 (4.00)^{a}	14.30	74.07	146.22	2.11
Triazophos (0.04%)	14.17 (3.89)^{c}	15.12 (4.01)^{a}	14.64	80.97	148.68	2.18
Imidacloprid (0.0178%)	14.37 (3.92)^{bc}	13.53 (3.81)^{b}	13.95	83.52	122.53	2.03
Dichlorvos (0.018%)	16.87 (4.23)^{a}	15.46 (4.05)^{a}	16.16	115.45	154.28	2.51
NSKE (5.0 ml/l)	9.66 (3.26)^{d}	7.26 (2.87)^{c}	8.46	23.37	19.41	0.84
Control	7.83 (2.97)^{e}	6.08 (2.66)^{d}	6.95			0.51
CD (P=0.05)	(0.16)	(0.18)				

[1]Figures in the parentheses are square root transformed means; [2]Based on the mean yield of two years

73.33 per cent mortality of *P. brassicae* by commercial neem formulations, viz. Achook and Nimbecidine when applied @ 4.0 kg/ha on cabbage crop in the field. Seljasen and Meadow (2006) also reported commercial neem formulation (NeemAzal-T) to have repellent effect for oviposition against *Mamestra brassicae* L. when applied @ 0.5 per cent on cabbage. Reductions in oviposition by the noctuid moth *Spodoptera litura* (F.) on neem treated plants were observed by Naumann and Isman (1995). The less effectiveness of homemade and farmer friendly preparation of NSKE in the present studies may be due to various reasons. It is possible that active ingredient (azadirachtin) in the crude NSKE must have been lower than refined commercial preparations. Likewise, the dosage used in the present investigations would have been lower for the aqueous extract to be effective. It is also quite possible that NSKE sprays after the onset of pest activity are not as effective as prophylactic sprays in discouraging the adult *P. brassicae* from laying eggs on the targeted crop.

SUMMARY

Five insecticides, i.e. lambda cyhalothrin 5 EC [Bravo5000®] (0.0025%), profenofos 50 EC [Profenofos®] (0.05%), triazophos 40 EC [Hostathion®] (0.04%), imidacloprid 17.8 SL [Maharaja®] (0.0178%), dichlorvos 76 EC [Nuvan®] (0.018%) and aqueous neem seed kernel extract (5.0 ml/L) were evaluated for the management of *Pieris brassicae*. Experiments were conducted in randomised block design (RBD) with three replications at research farm of Highland Agricultural Research and Extension Centre, Kukumseri, Lahaul and Spiti, Himachal Pradesh during *kharif* 2008 and 2009. It was concluded that all the insecticides evaluated in the present studies were effective in controlling *P. brassicae* on cauliflower and helped in increasing the marketable yield of curds by manifolds. However, lambda cyhalothrin was best in reducing the *P. brassicae* population, whereas triazophos gave highest reduction in plant infestation by *P. brassicae*. NSKE was least effective in curtailing *P. brassicae* infestation. The highest mean yield (16.16 tonnes/ha) was obtained in dichlorvos sprayed plots which also proved to be the most economical insecticide having the highest BC ratio (2.51).

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