

Comparative Efficacy of Botanical and Synthetic Pesticides against Major Insect Pests of Cabbage

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Abstract:

The efficacy of different botanical and synthetic pesticides against major insect pests of cabbage was carried out at Research Farm of Faculty of agriculture, Rawalakot (AJK), Pakistan. The experiment was laid out in a three replicated split-split plot design. Three cabbage varieties (Green Charm, Alphet and Prize) were sprayed with Cypermethrin, Neem seed crude extract, Eucalyptus leaves extract and Control was kept to check their efficacy. The efficacy against armyworm on cabbage varieties Green Charm, Alphet and Prize for Cypermethrin after 7 days of 1st spray was 89.51, 90.10 and 93.37%, Neem crude extract 79.63, 80.79 and 87.13%; Eucalyptus crude extract 79.05, 80.24 and 86.76%; 7 days after 2nd spray the efficacy of

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Cypermethrin was 92.77, 93.21 and 95.62%; Neem crude extract 79.94, 81.07 and 87.32; Eucalyptus crude extract 76.80, 78.12 and 85.34%; while 7 days after 3rd spray the efficacy of Cypermethrin was 92.05, 92.48 and 94.88%; Neem crude extract 79.83, 80.96 and 87.20; Eucalyptus crude extract 76.99, 78.30 and 85.54%, respectively. The efficacy against diamond back moth on varieties Green Charm, Alphet and Prize of Cypermethrin after 7 days of 1st spray was 85.71, 88.29 and 90.43%; Neem crude extract 82.19, 84.19 and 84.65%; Eucalyptus crude extract 78.51, 82.24 and 81.53% after 7 days of 1st spray, respectively. 7 days after 2nd spray, efficacy of Cypermethrin was 92.60, 93.02 and 95.32%, Neem crude extract 78.86, 80.05 and 80.65%; Eucalyptus crude extract 74.92, 76.34 and 78.00%; while 7 days after 3rd spray, the efficacy of Cypermethrin was 91.66, 92.14 and 94.73%; Neem crude extract 79.55, 80.71 and 83.22; Eucalyptus crude extract 76.80, 78.12 and 80.96%, respectively. The efficacy against maggots and on varieties Green Charm, Alphet and Prize of Cypermethrin after 7 days of 1st spray was 74.68, 79.24 and 90.12%, Neem crude extract 45.47, 52.99 and 53.86%; Eucalyptus crude extract 43.90, 51.98 and 52.46%; 7 days after 2nd spray, efficacy of Cypermethrin was 92.52, 92.94 and 95.20%, Neem crude extract 64.62, 66.62 and 66.95%; Eucalyptus crude extract 37.30, 45.77 and 61.11%; while 7 days after 3rd spray, the efficacy of Cypermethrin was 87.85, 88.65 and 91.94 %, Neem crude extract 66.09, 64.06 and 67.79; Eucalyptus crude extract 41.79, 48.70 and 67.40%, respectively. Cypermethrin showed markedly higher efficacy against Cabbage maggots as compared to Neem seed crude extract and Eucalyptus leaves extract. The differences in the efficacies of Neem seed crude extract and Eucalyptus leaves extract were not so pronounced in variety "Prize", while differences were significant when compared with efficacy of Cypermethrin in all varieties. The varietal response showed that cabbage variety "Prize" was better in response to insecticides for cabbage maggots management and had some better resistance against the cabbage maggots as compared to varieties "Green Charm" and "Alphet".

Key words: Efficacy, Synthetic pesticides, botanical extracts, cabbage, varieties, armyworm, diamondback moth, maggots

INTRODUCTION

Cabbage is a popular cultivar of the species (*Brassica oleracea* L.) of the family Brassicaceae (Cruciferae). Cabbage is a perennial plant and is characterized by a small stem which have crowded leaves (Olsson and Jonasson, 1994; Vanninen *et al.*, 1999; Trdan *et al.*, 2005). There are many insect pests that damage the cabbage crop (*Brassicaceae oleracea* L.). However, cabbage maggots, diamondback moth and armyworm are the most destructive insect pests of cabbage. The larvae of diamondback moth are of small size and are very harmful for cabbage plant. The adult diamondback moth lay eggs on the undersides of lower leaves. The eggs may be laid singly or in clusters. The eggs of diamondback moth are small, somewhat yellowish in color and foot-ball shaped. Larvae are yellowish green and small. The larvae of diamondback moth have a fringed tail. The length of adult larvae is 5/16 inch. The pupae are present mostly on stems or leaves of the cabbage. The body of the moth is a small, slender and with folded wings. The wings of the male meet and form three yellow diamond-shaped spots. Larvae feed on whole plant parts, but it mostly feed around the bud of small transplants. The young larvae crawl and make mine between the lower and upper leaf areas. Older larvae create irregular shot mines while leaving the upper surface intact, when the leaf of cabbage plant is disturbed. (Bessin, 2010).

The armyworm is a major insect pest of cabbage crop, which is a black to light-green and has four pairs of abdominal pro legs. The head of armyworm is dark. There is a prominent black spot on each side just above the second pair of the legs. Armyworm is very destructive for young plants. The armyworm larvae considerably reduce the cabbage yield. Smaller larvae often produce fine webbing near these feeding areas. The older plants quickly defoliate. Armyworm should be controlled at

proper time. It becomes very difficult to overcome the population of armyworm once larvae become 1/2 inch or longer than 1/2 inch. So timing of application is very important for the control of armyworm and treatment must be applied against young larvae. These pests can be observed easily and controlled effectively (Bessin, 2010).

Maggot is also one of the major insect pest of cabbage and is very destructive for cabbage plant. The maggots are the white insects and have no legs. The maggots feed into the stems and roots of the cabbage. They are rounded at the rear and pointed toward the head. These maggots mostly attack the tap roots, either feed on small roots or make tunnel into older roots. The maggots also make tunnels into stem of the plants. Due to winding tunnels, the infested plant becomes wilted. Secondary pathogens are often introduced and gathered within these wounds. During the heat of the day the infested plant may look wilted, brownish or stunted. Cool weather favors for cabbage maggot infestations. Insecticides coverage and timing of application is very important for control of cabbage maggots. For successful control of cabbage maggots proper identification of pest species is very necessary (Bessin, 2010).

Moreover, the insect diversify according to the climatic conditions, as cabbage tolerant relatively a low temperature. For this reason cabbage can be grown under a range of conditions. In Europe, white cabbage is grown in open, and so it is exposed to various insect pests. The insects that cause most problems are cabbage white butterfly (*Pieris brassicae* [L.]) (Olsson and Jonasson, 1994), diamond-back moth (*Plutella xylostella* [L.]), onion thrips (*Thrips tabaci* Lindeman) (Trdan *et al.*, 2005), and Swede midge (*Contarinia nasturtii*) (Frey *et al.*, 2004), cabbageroot flies (*Delia radicum* L. and *D. floralis* (Fall.) (Vanninen *et al.* 1999). Only recently have stink bugs of the genus *Eurydema* (Heteroptera: Pentatomidae) begun to damaging cultivated plants in Europe. The cabbage webworm,

Crocidolomia pavonana (F.), and the diamondback moth, *Plutella xylostella* (L.) are two major insect pests on cabbage and other brassicae crops. These insects severely harm the cabbage crop. The farmer use synthetic insecticides for controlling of these insect pests. The application of synthetic insecticides to overcome pests population on cabbage and other different vegetable crops such as chickpea, cauliflower and ladyfinger is still intensive due to its efficient, practical use, as well as fast effectiveness (Dadang *et al.*, 2009). The farmers use synthetic pesticides three to four times during a week. The whole number of insecticides applications on cabbage in one season could reach thirty to thirty four times. At least, about seventy to seventy five percent farmers invest money for insecticides about twenty five to thirty percent out of total production input cost. The excessive and misuse of synthetic pesticides have some harmful effects. It disturbed our farmland environment and also have some bad effects on human due to it's residue in the food. In many parts of the world pesticides residue in farmland yield especially in fruits and vegetables is a growing concern for, traders, growers, and consumers. Therefore, several strategies have been made to overcome the use of these synthetic pesticides. One of the strategies is the use of plant origin pesticides which is the novel and safer alternative effort to overcome the use of synthetic pesticides. Plant origin insecticides, which have plant extracts as active ingredients, are environmentally friendlier and safer as compared to synthetic pesticides (Rauf *et al.*, 2005). Therefore, this research was carried out to determine the comparative efficacy of synthetic and plant origin pesticides against major insect pests of cabbage, and to compare cabbage varieties for their relative resistance against these insect pests.

MATERIALS AND METHODS

The experiment was laid out in a three replicated split-split plot design. Land was well worked by practicing dry ploughing, followed by clod crushing and leveling. The soil was planked for eradication of weeds and to make the surface leveled for uniform distribution of irrigation water. When the land came in condition after soaking dose, cross-wise cultivator was run, followed by a rotavator. Thus, a good seed bed was prepared. The seed for nursery was sown on 06.05.2012; and when the nursery attained the age of 32 days, it was transplanted on ridges of a good prepared seed bed on 08.07.2012. The sowing of cabbage was done by transplanting the raised seedlings keeping 60 cm row to row spacing and plants were spaced at 45 cm. Organic matter is used as fertilizer for better growth of cabbage. Three varieties (Green charm, Alphet and Prize) were sprayed with Cypermethrin, Neem seed crude extract and Eucalyptus leaves extract and a control was kept to compare the efficacy.

Chemical control: Cypermethrin 10ml EC was purchased from the local market and dosage was used as per the label on the bottle using knapsack hand sprayer.

Neem seed crude extract: Foliar spray of the extract was carried out with knapsack sprayer). Neem seeds collected, dried and then crushed using a crusher to yield consistent size of fine particles. Then the fine particles of neem seed were drenched in methanol (1:10; w/v) for 48 hours. The neem extract solution filtered with the help of filter paper (Whatman No. 1). The methanol which was present in the solution was evaporated with a rotary evaporator under reduced pressure (400-450 mmHg.) at 50°C. The crude extracts were kept in low temperature (-4°C) in the refrigerator and used.

Eucalyptus leaves extract: Eucalyptus leaves collected, dried and then crushed using a crusher to yield consistent size of fine particles. Then the fine particles of eucalyptus was drenched in methanol (1:10; w/v) for 48 hours. The eucalyptus extract solution filtered with the help of filter paper (Whatman No. 1). The methanol which was present in the solution was evaporated with a rotary evaporator under reduced pressure (400-450 mmHg.) at 50°C. The crude extracts were kept at low temperature (-4°C) in the refrigerator and used.

The pesticide spraying was done in the morning time by knapsack sprayer. In case of Armyworm and Diamodback moth spraying was done on leaves while in case of Maggots spraying was done in stem region and near the root by wetting the soil. After spraying with each botanical pesticide, the spraying machine (knapsack hand sprayer) was thoroughly washed to avoid any residual effects from the preceding product sprayed. The observations on the incidence of insect pests were recorded as per the planned schedule. For this purpose, Observations were recorded on 5 plants and average per plant infestation was averaged. The post-treatment observations started after 24 hours of spray. In all three sprays were conducted after 30 days interval and observation process of first spray was repeated also for the second and third spray. The observations were recorded at morning hours (8-10 a.m.). The population of the insect pests was examined carefully. The observations were recorded before spray and after 1m 3, 5 and 7 days of treatment. The efficacy of pesticides was calculated by the following formula:

$$\% \text{ Efficacy} = \frac{\text{Insect's mortality number}}{\text{Total number of Insects}} \times 100$$

The data thus recorded were subjected to analysis of variance to record the level of significance for variation following the

methods suggested by Steel and Torrie (1980). L.S.D. test was also employed to compare the average population under different botanical pesticides. The basis of statistical analysis, the results were interpreted and presented in the following chapter.

RESULTS

Efficacy of insecticides against Armyworm

Statistically the differences in the efficacy of different insecticides against army worm on cabbage were highly significant ($P < 0.01$), while differences were non-significant ($P > 0.05$) in efficacy between 1st, 2nd and 3rd spray. Most of the possible treatment interactions also showed significant ($P < 0.01$) differences in the efficacy of insecticides against armyworm on cabbage.

1. Variety “Green charm”

The efficacy of Cypermethrin against armyworm on cabbage variety Green Charm was highest (89.51%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 79.63 and 79.05 percent, respectively after 7 days of first spray. The efficacy of synthetic and botanical pesticides after second spray indicates that Cypermethrin was highly effective by showing 92.77 percent efficacy against armyworm after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 79.94 and 76.80 percent, respectively. After third spray, of various botanical and synthetic pesticides on variety Green Charm, Cypermethrin showed higher efficacy of 92.05 percent, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 79.83 and 76.99 percent, respectively after third spray (Table 1).

2. Variety “Alphet”

On cabbage variety “Alphet” the efficacy of Cypermethrin against armyworm was highest (90.10%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 80.79 and 80.24percent, respectively after 7 days of first spray. The efficacy of synthetic and botanical pesticides after second spray showed that Cypermethrin was highly effective to show 93.21percent efficacy against armyworm after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 81.07and 78.12 percent, respectively. After third spray of various botanical and synthetic pesticides on cabbage variety “Alphet” Cypermethrin against Armyworm demonstrated higher efficacy of 92.48percent, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 80.96 and 78.30percent, respectively after third spray (Table-2).

3. Variety “Prize”

On cabbage variety “Prize” the Cypermethrin efficacy against Armyworm was highest (93.37%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 87.13 and 86.76 percent, respectively after 7 days of first spray. The efficacy of synthetic and botanical pesticides after second spray showed that Cypermethrin was highly effective to result 95.62 percent efficacy against armyworm after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 87.32 and 85.34 percent, respectively. After third spray of various botanical and synthetic pesticides on cabbage variety “Prize” Cypermethrin against demonstrated higher efficacy of 94.88 percent, followed by Neem seed crude extract and

Eucalyptus leaves extract with average efficacy of 87.20 and 85.54 percent, respectively after third spray (Table-1).

It was observed that after 1 day of pesticidal spray, the efficacy of all pesticides was in the range of around 20-30 percent and efficacy increased markedly after 3, 5 and 7 days, the insecticides efficacy increased considerably reaching highest levels for respective insecticides after 7 days of each spray. Moreover, Cypermethrin showed a markedly higher efficacy against armyworm as compared to Neem seed crude extract and Eucalyptus leaves extract. The differences in the efficacies of Neem seed crude extract and Eucalyptus leaves extract were not so pronounced, while differences were significant when compared with efficacy of Cypermethrin. The varietal response showed that cabbage variety “Prize” was better in response to armyworm management by insecticides and probably had better relative resistance against the armyworm as compared to varieties “Green Charm” and “Alphet”. These results also confirmed by Basana and Prijono (1994); the neem extract and neem oil showed high efficacy against diamondback moth larvae. Similarly, these compounds together with asimisin have high toxic effect against *Plutella xylostella* (Ohsawa and Dadang, 1998). They also reported that the extract of *P. retrofractum* has high toxic activity against *P. xylostella* and *C. pavonana* (Dadang *et al.* 2009).

Table 1. Percent Efficacy of different botanical and synthetic pesticides against Army worm on three cabbage varieties after 1, 3, 5 and 7 days after 1st, 2nd and 3rd spray

	CABBAGE VARIETIES											
	GREEN CHARM				ALPHET				PRIZE			
	1DAS	3DAS	5DAS	7DAS	1DAS	3DAS	5DAS	7DAS	1DAS	3DAS	5DAS	7DAS
After 1st Spray												
Cypermethrin	32.31	53.00	73.66	89.51a	36.15	59.48	77.29	90.10a	41.25	66.37	83.42	93.37a
Neem Extract	24.73	45.13	59.20	79.63b	28.99	52.70	64.83	80.79b	34.67	60.74	74.33	87.13b
Eucalyptus	14.95	27.56	50.83	79.05b	19.76	37.55	57.61	80.24b	26.18	48.17	69.05	86.76b
After 2nd Spray												
Cypermethrin	21.67	45.30	65.18	92.77a	26.13	52.91	70.05	93.21a	32.09	61.01	78.28	95.62a
Neem Extract	21.56	36.48	59.35	79.94b	26.13	45.24	64.95	81.07b	31.92	54.55	74.42	87.32b
Eucalyptus	21.56	53.65	65.70	76.80c	26.00	60.04	70.43	78.12c	31.92	66.83	78.41	85.34c
After 3rd Spray												
Cypermethrin	21.50	44.94	64.67	92.05a	25.93	52.50	69.51	92.48a	31.84	60.53	77.67	94.88a
Neem Extract	21.53	36.43	59.26	79.83b	25.96	45.18	64.86	80.96b	31.87	54.47	74.31	87.20b
Eucalyptus	21.61	53.77	65.85	76.99b	26.06	60.18	70.59	78.30c	31.99	66.99	78.60	85.54c

	Pesticides	Sprays	Obs. Interval	Varieties
S.E.	0.5970	0.5170	0.3020	0.0249
LSD 0.05	1.4609	NS	0.6232	0.0498
LSD 0.01	1.9169	NS	0.8446	0.0662

Efficacy of insecticides against Diamond back moth

The efficacy of different insecticides against diamond back moth for varieties and observation interval was highly significant ($P < 0.01$), while non-significant ($P > 0.05$) between 1st, 2nd and 3rd spray.

1. Variety “Green charm”

The efficacy of Cypermethrin against diamond back moth on cabbage variety “Green Charm” was highest (85.71%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 82.19 and 78.51 percent, respectively after 7 days of first spray. The efficacy of synthetic and botanical pesticides after second spray indicates that Cypermethrin was highly effective to show 92.60 percent efficacy against diamond back moth after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 78.86 and 74.92 percent, respectively. After third spray, of various botanical and synthetic pesticides on cabbage variety “Green Charm”, Cypermethrin showed higher efficacy of 91.66 percent, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 79.55 and 76.80 percent, respectively after third spray (Table-2).

2. Variety “Alphet”

The efficacy of Cypermethrin against diamond back moth on cabbage variety “Alphet” was highest (88.29%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with

average efficacy of 84.19 and 82.24 percent, respectively after 7 days of first spray. The efficacy of synthetic and botanical pesticides after second spray showed that Cypermethrin was highly effective to show 93.02 percent efficacy against diamond back moth after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 80.05 and 76.34 percent, respectively. After third spray of various botanical and synthetic pesticides on cabbage variety "Alphet" Cypermethrin again demonstrated higher efficacy of 92.14 percent, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 80.71 and 78.12 percent, respectively after third spray (Table-2).

3. Variety "Prize"

Cypermethrin efficacy against Diamond back moth infesting cabbage variety "Prize" was highest (90.43%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 84.65 and 81.53 percent, respectively after 7 days of first spray. The efficacy of synthetic and botanical pesticides after second spray showed that Cypermethrin was highly effective to result 95.32 percent efficacy against diamond back moth after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 80.65 and 78.00 percent, respectively. After third spray of various botanical and synthetic pesticides on cabbage variety "Prize" Cypermethrin again demonstrated higher efficacy of 94.73 percent, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 83.22 and 80.96 percent, respectively (Table-2).

It was also observed that after 24 hours (1 day) of spray, the efficacy of all insecticides was in the range of around 10-45 percent and efficacy increased markedly after 3, 5 and 7 days, reaching highest levels for respective insecticides after 7 days of

each spray. Moreover, Cypermethrin showed markedly higher efficacy against Diamond back moth as compared to Neem seed crude extract and Eucalyptus leaves extract. The differences in the efficacies of Neem seed crude extract and Eucalyptus leaves extract were not so pronounced, while differences were significant when compared with efficacy of Cypermethrin. The varietal response showed that cabbage variety “Prize” was better in response to insecticides for diamond back moth management and had some better resistance against the diamond back moth as compared to varieties “Green Charm” and “Alphet”. These results are in line with many past researchers who reported that neem and Dhatura extract also have high destructive effect on several test insects including *C. pavonana* and *P. xylostella*. The extract of *P. retrofractum* has also known to have insecticidal activity to *Forficula auricularia* (Dermaptera: Forficulidae), *Culex quinquefasciatus* and *Aedes aegypti* (Diptera: Culicidae), and *Coptotermes gestroi* (Isoptera:Rhinotermitidae) (Chansang *et al.* 2005; Alfian, 2007). Neem and Piperamide based products possess methylendioxyphenyl and isobutylamide moieties with high insecticidal toxicity that effects on the nervous system of the insects by inhibiting the nerve impulse (Miyakado *et al.*, 1989). It was observed that *A. odorata* extract has high effectiveness against several insect pests including *P.xylostella* and *C. pavonana* larvae. Ninety two % larval mortality of *C. pavonana* was observed when treated with 1.0% extract of *A. odorata*. (Dadang *et al.*, 2009).

Table 2. Efficacy (%) of different botanical and synthetic pesticides against Diamond-back Moth on three cabbage varieties after 1, 3, 5 and 7 days after 1st, 2nd and 3rd spray.

	CABBAGE VARIETIES											
	GREEN CHARM				ALPHET				PRIZE			
	1DAS	3DAS	5DAS	7DAS	1DAS	3DAS	5DAS	7DAS	1DAS	3DAS	5DAS	7DAS
After 1st Spray												
Cypermethrin	37.88	51.13	74.05	85.71a	41.40	57.87	69.90	88.29a	46.09	65.03	81.06	90.43a
Neem Extract	21.77	36.12	63.24	82.19b	26.26	44.93	68.31	84.19b	32.10	54.29	76.87	84.65b
Eucalyptus	4.68	35.97	61.77	78.51c	10.08	44.80	67.04	82.24c	17.27	54.18	75.94	81.53c
After 2nd Spray												
Cypermethrin	24.74	47.29	66.27	92.60a	29.00	54.56	70.92	93.02a	34.68	62.28	78.77	95.32a
Neem Extract	17.32	33.04	57.15	78.86b	29.00	42.28	63.06	80.05b	28.24	52.09	73.03	80.65b

Mazhar Iqbal, Abdul R. Khan, Muhammad Rafique, Velo Suthar, Bhai. K. Solangi-
Comparative Efficacy of Botanical and Synthetic Pesticides against Major Insect Pests of Cabbage

Eucalyptus	15.20	49.89	62.92	74.92c	22.00	56.80	68.03	76.34c	26.40	64.14	76.66	78.00c
After 3rd Spray												
Cypermethrin	15.20	40.61	61.99	91.66a	20.00	48.80	67.23	92.14a	26.40	57.50	76.08	94.73a
Neem Extract	27.92	44.00	69.76	79.55b	32.00	51.72	73.93	80.71b	37.44	59.93	75.75	83.22b
Eucalyptus	21.56	53.65	65.70	76.80c	26.00	60.04	70.43	78.12c	31.92	66.83	78.41	80.96c

	Pesticides	Sprays	Obs. Interval	Varieties
S.E.	0.2937	0.2544	0.1917	0.0495
LSD 0.05	0.7188	0.6225	0.3957	0.0988
LSD 0.01	1.0890	0.9431	0.5362	0.1313

Efficacy of insecticides against Cabbage maggots

Statistically the differences in the efficacy of various botanical and synthetic insecticides against cabbage maggots, between treatments, observation intervals and varieties were highly significant ($P < 0.01$), while differences in efficacy were non-significant ($P > 0.05$) between 1st, 2nd and 3rd spray. The treatment interactions also showed significant ($P < 0.01$) differences in the efficacy of insecticides against cabbage maggots.

1. Variety “Green charm”

The efficacy of Cypermethrin against cabbage maggots on variety “Green Charm” was highest (74.68%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 45.47 and 43.90 percent, respectively after 7 days of first spray. The efficacy of synthetic and botanical pesticides after second spray demonstrates that Cypermethrin was highly effective to result 92.52 percent efficacy against cabbage maggots after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 64.62 and 37.30 percent, respectively. After third spray, of various botanical and synthetic pesticides on cabbage variety “Green Charm”, Cypermethrin showed higher efficacy of 87.85 percent, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 66.09 and 41.79 percent, respectively (Table 3).

2. Variety “Alphet”

Against cabbage maggots on cabbage variety “Alphet”, the efficacy of Cypermethrin was highest (79.24%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 52.99 and 51.98 percent, respectively after 7 days of first spray. The results for second spray showed that Cypermethrin show higher efficacy 92.94 percent against cabbage maggots after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 66.62 and 45.77 percent, respectively. After third spray of various botanical and synthetic pesticides on cabbage variety “Alphet” Cypermethrin again resulted in higher efficacy of 88.65 percent, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 64.06 and 48.70 percent, respectively (Table 3).

3. Variety “Prize”

The efficacy of Cypermethrin against Cabbage maggots infesting cabbage variety “Prize” was highest (90.12%) after 7 days of first spray, which was markedly higher than the efficacy of Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 53.86 and 52.46 percent, respectively after 7 days of first spray. The efficacy of synthetic and botanical pesticides after second spray showed that Cypermethrin was highly effective to result 95.20 percent efficacy against cabbage maggots after 7 days of second spray, followed by Neem seed crude extract and Eucalyptus leaves extract with average efficacy of 66.95 and 61.11 percent, respectively. After third spray of various botanical and synthetic pesticides on cabbage variety “Prize” Cypermethrin again demonstrated higher efficacy of 91.94 percent, followed by Neem seed crude extract and Eucalyptus leaves extract with

average efficacy of 67.79 and 67.40 percent, respectively (Table 3).

The data showed that after 24 hours of spray, the efficacy of all insecticides was in the range of around 20-50 percent and efficacy increased markedly after 3, 5 and 7 days, reaching highest levels for respective insecticides after 7 days of each spray. Moreover, Cypermethrin showed markedly higher efficacy against Cabbage maggots as compared to Neem seed crude extract and Eucalyptus leaves extract. The differences in the efficacies of Neem seed crude extract and Eucalyptus leaves extract were not so pronounced in variety "Prize", while differences were significant when compared with efficacy of Cypermethrin in all varieties. The varietal response showed that cabbage variety "Prize" was better in response to insecticides for cabbage maggots management and had some better resistance against the cabbage maggots as compared to varieties "Green Charm" and "Alphet". Similar results have also been reported by other research workers in different parts of the world. The hundred percent mortality of *Spodoptera litura* (Lepidoptera:Noctuidae), was recorded when treated with ethanol twig extract of *A. odorata*, isolated six botanical compounds from *A. odorata*, which were conscientious for mortality, feeding inhibition, and growth regulatory activity against *Spodoptera littoralis* (Sudarmo, 2001). The mixture of these extract in formulation will produce a good plant origin pesticide formulation. Dadang *et al.* (2009) reported that the mixture of *P. retrofractum* with *A. squamosa* and *A. odorata* with *A. squamosa* showed high efficacy against *C. pavonana* and produced 100% and 94% mortality when *C. pavonana* larvae were treated with 0.05% extract mixture at 48 hours after treatment. Moreover, the formulations should contain two or more plant extracts to make the formulation more efficient in using plant materials, more economic in extract and formulation preparations, and more effective in toxicity and

slow down the development of insect resistance (Dadang *et al.* 2009). Another important matter in the application of botanical insecticide formulation should be its compatibility with other integrated pest management strategies. This discussion clearly suggested that botanical pesticides can do equally good control of insect pests as observed in the case of synthetic pesticides. Further studies may be carried out to confirm these results.

Table 3. Efficacy (%) of different botanical and synthetic pesticides against cabbage maggots on three cabbage varieties after 1, 3, 5 and 7 days after 1st, 2nd and 3rd spray.

	CABBAGE VARIETIES											
	GREEN CHARM				ALPHET				PRIZE			
	1DAS	3DAS	5DAS	7DAS	1DAS	3DAS	5DAS	7DAS	1DAS	3DAS	5DAS	7DAS
After 1st Spray												
Cypermethrin	48.32	51.16	54.01	74.68a	48.84	69.25	72.61	79.24a	52.45	59.47	78.84	90.12a
Neem Extract	33.87	35.17	36.75	45.47b	36.75	39.89	41.60	52.99b	39.91	47.70	52.05	53.86b
Eucalyptus	16.06	21.46	25.25	43.90c	17.70	30.49	34.43	51.98c	22.64	40.92	48.85	52.46c
After 2nd Spray												
Cypermethrin	28.39	49.84	65.89	92.52a	32.44	56.76	70.60	92.94a	37.85	64.11	77.36	95.20a
Neem Extract	17.46	56.33	63.32	64.62b	19.94	53.71	62.95	66.62b	41.77	63.75	67.72	66.95b
Eucalyptus	21.16	28.84	34.04	37.30c	26.06	33.60	38.36	45.77c	27.51	40.56	55.00	61.11c
After 3rd Spray												
Cypermethrin	13.57	39.47	61.26	87.85a	18.47	47.82	66.60	88.65a	24.99	56.69	75.62	91.94a
Neem Extract	33.11	52.51	60.11	66.09b	29.10	44.91	53.73	64.06b	38.47	60.58	62.90	67.79b
Eucalyptus	22.71	31.70	35.80	41.79c	27.09	40.92	42.36	48.70c	32.92	43.31	65.97	67.40b

	Pesticides	Sprays	Obs. Interval	Varieties
S.E.	0.2490	0.2156	0.0847	0.0531
LSD 0.05	0.6093	-	0.1749	0.1061
LSD 0.01	0.9232	-	0.2370	0.1410

Table 4. Mean squares corresponding to efficacy of different types of insecticides against various insect pests of cabbage

Source of variation	DF	Armyworm	Diamond Back moth	Cabbage maggots
Spray (A)	2	9.313 ^{NS}	0.248 ^{NS}	0.7975 ^{NS}
Treatment (B)	3	576.856**	126.121**	23.2508**
Error A*B	6	6.416	1.553	1.1160
Interval (C)	3	109.963**	59.266**	4.4315**
B*C	9	11.708**	7.142**	0.9259**
Error A*B*C	24	1.641	0.662	0.1293
Varieties (D)	2	14.938**	4.589**	1.3010**
B*D	6	0.594**	0.160*	0.0650 ^{NS}
C*D	6	0.674**	0.382**	0.0517 ^{NS}
B*C*D	18	0.058**	0.042 ^{NS}	0.0194 ^{NS}
Error A*B*C*D	64	0.15	0.059	0.0677
Total	143			

** Significant at P<0.01, *Significant at P<0.05 and ^{NS} Non-Significant

Conclusions

1. After 24 hours of spray, the efficacy of all insecticides was in the range of around 20-50 percent and efficacy increased markedly after 3, 5 and 7 days, reaching highest levels for respective insecticides after 7 days of each spray.
2. Cypermethrin showed markedly higher efficacy against Cabbage maggots Army worm and Diamondback moth as compared to Neem seed crude extract and Eucalyptus leaves extract.
3. Cabbage variety "Prize" showed some better resistance against cabbage insect pests management as compared to varieties "Green Charm" and "Alphet".
4. Variety Prize proved to have relative resistance against insect pests, while Cypermethrin proved to be highly effective to combat with cabbage insect pests.

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