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Bio-efficacy of certain botanicals and bio-pesticides against diamondback moth, (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* var. *capitata* L.) under field condition

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Abstract
Field experiment was conducted to study the Bio-efficacy of certain botanicals and bio-pesticides against diamondback moth, (*Plutella xylostella* L.) on cabbage were carried out during *rabi* season in 2019-20 and 2020-21 at Student's Instructional Farm (SIF) of the Department of Agronomy, C. S. Azad University of Agriculture and Technology, Kanpur Uttar Pradesh, India on cabbage variety *Savitri.* The *P. xylostella* was active throughout the year with a varying degree of infestation. *Bacillus thuringiensis* var. *kurstaki* (Dipel 8 L) @ 0.2% as spray on standing crop with 41.85% population reduction over control proved best among all treatments by reducing mean number of larvae 0.48/plant. The second most effective treatment applied to the cabbage on standing crop as spray form was *Beauveria bassiana* 1.15% WP @ 0.2% with 38.30% population reduction over control with mean number of larvae 0.75/plant, followed by Nimbicidine 0.15% EC (Azardirachtin 1500 ppm) @ 0.3% (37.29%), *Datura* (*Datura stramonium* L.), leaf extract @ 5% (34.06%), Tobacco (*Nicotiana tabacum* L.), leaf extract @ 5% (32.36%), *Lantana* (*Lantana camera* L.), leaf extract @ 5% (26.43%) and *Aak* (*Calotropis gigantea* L.), leaf extract @ 5% (24.06%) with mean number of larvae 0.84, 1.12, 1.29, 1.83 and 2.08/plant respectively, but it was statistically superior in comparison to control in which 4.98 mean larvae were recorded. In this experiment we observed that the botanical bio-pesticides proved best to manage the diamondback moth (DBM) population on cabbage crop.

Keywords: Cabbage, *P. xylostella*, *Bacillus thuringiensis*, bio-pesticides, *Beauveria bassiana*

Introduction
Cabbage, *Brassica oleracea* var. *capitata* L. is one of the most important cultivated vegetable grown in India, which belongs to the family cruciferae. In India, it is grown extensively in tropical and temperate regions and believed to have originated from Western Europe and Mediterranean region (Khan *et al*., 2017) [7]. India is the second largest producer of cabbage in the world after china, accounting for 16.55 per cent of the world area and 12.79 per cent of the world production. In India, the crop is cultivated in almost all the states occupying an area of about 0.40 million hectares with the total production of about 9.59 million tonnes and average productivity of 22.68 tonnes/hectares. In Uttar Pradesh, the area under cultivation of cabbage is about 9.06 thousand hectares with the production of about 302.97 thousand tonnes and average productivity of 33.44 tonnes/hectares. (Anonymous, 2019-20) [2]. The daily per capita availability of vegetable in India is 401 gm which is higher than the requirement of about 300 gm for a balanced diet. Vegetables form an integral part of human diet and are regarded as an important source of carbohydrates, proteins, vitamins, minerals and fibers for human being. The nutritional value per 100 g of cabbage consists of carbohydrates 5.8 g, fat 0.1 g, protein 1.28 g, vitamins (thiamine or vitamin B_1 0.061 mg, riboflavin or vitamin B_2 0.040 mg, niacin or vitamin B_3 0.234 mg, pantothenic acid or vitamin B_5 0.212 mg, folate or vitamin B_9 43 mg, vitamin C 36.6 mg, and vitamin K 76 mg) and minerals (Ca 40 mg, Fe 0.47 mg, Mg 12 mg, Mn 0.16 mg, P 26 mg, K 170 mg, Na 18 mg and Zn 0.18 mg), (Sharma *et al.*, 2017) [11]. The major constraint in the production of cabbage is pest complex right from germination to harvest. The cabbage crop has a multiple insect pest complex, among them the important insect pest species are diamondback moth (DBM), *Plutella xylostella* Linnaeus; head borer, *Hellula undalis* Fabricius; mustard sawfly, *Athalia lugens proxima* Klug; leaf webber, *Crocidolomia binotalis* Zeller; cabbage aphid, *Brevicoryne brassicae* Linnaeus; cabbage butterfly, *Pieris brassicae* Linnaeus and cabbage semilooper, *Trichoplusia ni* Hubner etc.

In India diamondback moth was first recorded in 1914 on crucifer vegetables (Fletcher, 1914) [5] and is now the most devastating pest of cole crops in the states of Punjab, Haryana, Himachal Pradesh, Delhi NCR, Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra and Karnataka. Diamondback moth (DBM), has gained the status of most destructive insect-pest of cruciferous crops throughout the world (Singh *et al*., 2005) [12].

The per cent yield loss in cabbage due to insect pests ranged from 19.24 to 30.30 per cent with an average of 25.80 per cent (Jat *et al*., 2017) [6]. Out of these, diamondback moth, *Plutella xylostella* L. is the most destructive and cosmopolitan pest (Mahla *et al*., 2005) [9]. In India, diamond back moth has national importance on cabbage as it causes 50-80% annual loss in the marketable yield (Devjani and Singh, 1999) [4]. In India, Krishnamoorthy, 2004 [8] also reported 52% yield loss on cabbage due to the attack of diamondback moth. Excessive use of chemicals to control this pest not only causes the economical restrain on farmers but also produces the harmful side effects on the environment as well as human being. The best way to overcome this situation is to destroy the pest at its initial stage of the life cycle. This is possible if timely prediction of the occurrence of the pest can be made. Hence, an investigation on evaluation of certain bio-pesticides against diamondback moth, *Plutella xylostella* L. on cabbage was carried out.

Materials and Methods

The field experiments were conducted during *rabi* 2019-20 and 2020-21, at Student's Instructional Farm (SIF) of the Department of Agronomy, C. S. Azad University of Agriculture and Technology, Kanpur Uttar Pradesh. The experiments were conducted in Randomized complete block design (RCBD) manner with eight treatments including control and three replications with total number of 24 plots. The seedlings of cabbage variety *Savitri* were procured from Vegetable Research Station, Kalyanpur, Kanpur and planting with a plot size 4.5 x 2.25 m and spacing 45 x 45 cm during the 25th November 2019 and 23th November 2020 for both the years. For present experiment 30-35 days old seedlings of cabbage were transplanted in the field and all the recommended agronomical practices were followed to raise the crop. Single seedling was transplanted at a single spot and a light irrigation was provided after planting of the seedlings. Only the healthy plants were allowed to grow and weaker and dead plants were replace by gap filling process after one week of transplanting. The first spraying was done at 60 days after transplanting (DAT) and subsequently spraying was performed after 15 days of intervals. Spraying was done with the help of knapsack sprayer. All plots are sprayed with allotted botanicals bio-pesticide except control plot which was sprayed with water only. The observations were recorded on the population of diamondback moth larvae of five randomly selected plants in each plot on one day before every spray which served as pre-treatment observation and the subsequent count were taken on 3rd, 7th, and 14th days after each spray (Post-treatment) and the observation on the larval population of diamondback moth was recorded during morning hours (Devi and Tayde 2017) [3].

Table 1: Recommended dose of botanical bio-pesticides for diamondback moth as spray

S. No.	Name of bio-pesticides	Dose/liter water	Concentration of bio-pesticides
1.	*Bacillus thuringiensis* var. *kurstaki* (Dipel 8L)	2 ml	0.20%
2.	Nimbicidine 0.15% EC (Azardirachtin 1500 ppm)	3 ml	0.30%
3.	*Beauveria bassiana* 1.15% WP	2 ml	0.20%
4.	*Datura* (*Datura stramonium* L.), leaf extract	50 ml	5.0%
5.	*Lantana* (*Lantana camera* L.), leaf extract	50 ml	5.0%
6.	*Aak* (*Calotropis gigantea* L.), leaf extract	50 ml	5.0%
7.	Tobacco (*Nicotiana tabacum* L.), leaf extract	50 ml	5.0%
8.	Untreated (Control)	-	-

Results and Discussion

The results of pooled data showed that all the bio-pesticides were found to be significantly superior over control (Untreated) in reducing the population of diamondback moth at 3rd, 7th and 14th days after 1st, 2nd and 3rd spray of bio-pesticides. *Bacillus thuringiensis* var. *kurstaki* (Dipel 8 L) @ 0.2% with 39.05 percent reduction over control (PROC) proved best among all treatments in 3rd days after 1st, 2nd and 3rd spray by reducing mean number of 0.60 larvae per plant. The second most effective treatment applied to the cabbage was *Beauveria bassiana* 1.15% WP @ 0.2% with 38.01 percent reduction over control (PROC) with mean number of 0.68 larvae per plant. Treatment Aak (*Calotropis gigantea* L.), leaf extract @ 5% was found most inferior among all the treatments with 22.03 per cent reduction over control (PROC) with mean number 2.05 larvae per plant but it was statistically superior in comparison to control in which 4.75 mean larvae per plant were recorded.

Bacillus thuringiensis var. *kurstaki* (Dipel 8 L) @ 0.2% with 41.34 percent reduction over control (PROC) proved best among all treatments in 7th days after 1st, 2nd and 3rd spray by reducing mean number of 0.44 larvae per plant, followed by *Beauveria bassiana* 1.15% WP @ 0.2% with 41.00 percent reduction over control (PROC) with mean number of 0.46 larvae per plant. Treatment Aak (*Calotropis gigantea* L.), leaf extract @ 5% was found most inferior among all the treatments with 25.08 per cent reduction over control (PROC) with mean number 1.79 larvae per plant but it was statistically superior in comparison to control in which 4.73 mean larvae per plant were recorded.

Bacillus thuringiensis var. *kurstaki* (Dipel 8 L) @ 0.2% with 41.85 percent reduction over control (PROC) proved best among all treatments in 14th days after 1st, 2nd and 3rd spray by reducing mean number of 0.48 larvae per plant. The second effective treatment applied to the cabbage was *Beauveria bassiana* 1.15% WP @ 0.2% with 38.30 percent reduction over control (PROC) with mean number of 0.75 larvae per plant. Treatment Aak (*Calotropis gigantea* L.), leaf extract @ 5% was found most inferior among all the treatments with 24.06 per cent reduction over control (PROC) with mean number 2.08 larvae per plant but it was statistically superior in comparison to control in which 4.98 mean larvae per plant

were recorded. The results of present investigation similar to the results of Vanlaldiki *et al*. (2013) [13] who conducted the field experiment to study the relative efficacy of different eco-friendly insecticides comprising of four neem product (nimbecidine, Agrineem, Vijayneem and Neemark), two Bt products (dipel and delfin), one entomopathogenic fungus, *Beauveria bassiana* (biorin*)* and a chemical insecticide (nuvan) against diamondback moth (*Plutella xylostella* L.) vis-à-vis their effect on the predatory coccinellid, *Coccinella septempunctata* L. All the insecticides were superior in controlling the diamondback moth population in comparison to untreated control. Amongst the different treatments, Bt. (dipel) recorded the lowest larval population (0.21/plant) and proved to be the most effective treatment, followed by Bt (delfin) and nuvan with larval populations of 0.45 and 1.50/plant respectively, as against 8.88/plant in untreated control. Vijayneem was found to be the most inferior insecticide by recording the highest population of 3.06/plant. The mean yield ranged from 17.92 to 22.73t/ha in insecticidal treatments with the maximum yield in dipel as against 14.75t/ah in untreated control. Devi and Tayde (2017) [3] who also reported that the comparative efficacy of some bio-agent (*Bacillus thuringiensis* and *Beauveria bassiana*) and botanicals (Neem oil, NSKE, Neem leaf, tobacco, dhatura and *Lantana camera*) along with an untreated control against *Plutella xylostella*. Field trial was conducted during *rabi* season 2016-17. Each insecticide was sprayed twice at 15 days interval. The larval count per plant was taken one day before and 3rd, 7th and 14th days after each spray. All the insecticides tested significantly reduced the pest population compared to control. The highest percent reduction of diamondback moth larvae against control was observed in *Bacillus thuringiensis* (61.22%).

In support of present results Ali *et al*. (2019) [1] also who reported that the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae) is one of the most notorious and cosmopolitan insect pests of brassica crops around the world. *Plutella xylostella* may cause 90% yield losses in brassica crops. Various control measures have been adopted to manage this pest however the most effective control method is the use of synthetic chemical insecticides. Over use of insecticides have many adverse effects including insecticide resistance, hazardous to environment, long persistency, interference with food chain. The results of present investigation corroborate with the results of Samanta *et al*. (2020) [10] who reported that the field experiment at Instructional farm of Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, WB, during *rabi* season of 2017-18 for the management of major insect pests of cabbage. Pooled data of three applications of eight different insecticidal treatments *viz*., Derisom (Karanjin 2% EC), Anosom (Annonin 1% EC), Margosom (Azadirachtin 0.15% EC), Dipel (*Bacillus thuringiensis var.* kurstaki), Biosar (*Verticillium lecanii*), Biocere (*Beauveria Bassiana*), Mahamaya (Novaluron @ 10% EC), Tracer (Spinosad 45% SC) and a natural control plot against diamondback moth, shows that Novaluron @ 10% EC was most effective in reducing the larval population of diamondback moth (67.9%) followed by Tracer @ 45% SC (54.5%) and *Bt. kurstaki* (53.3%). The highest yield was recorded in the plot treated with novaluron i.e 416.67 q/ha as compare to the untreated plot produce 193.4q/ha cabbage.

Table 2: Effect of different bio-pesticides on the larval population of diamondback moth on cabbage after 3rd, 7th and 14th DAS during 2019-20

S. N.	Treatments	Dose gm or ml/ ha	Larval population per plant														
			3 Days after spray (DAS)					7 Days after spray (DAS)					14 Days after spray (DAS)				
			1st	2nd	3rd	Mean	PROC	1st	2nd	3rd	Mean	PROC	1st	2nd	3rd	Mean	PROC
1.	*Bacillus thuringiensis* var. *kurstaki* (Dipel 8 L) @ 0.2%	2ml	0.20 (0.84)	0.40 (0.95)	1.19 (1.30)	0.59 (1.75)	38.59	0.15 (0.81)	0.35 (0.92)	0.80 (1.14)	0.43 (1.69)	41.31	0.20 (0.84)	0.60 (1.05)	0.60 (1.05)	0.46 (1.71)	41.63
2.	Nimbicidine 0.15% EC (Azardirachtin 1500 ppm) @ 0.3%	3ml	0.20 (0.84)	0.38 (0.94)	1.60 (1.45)	0.72 (1.79)	37.19	0.17 (0.82)	0.20 (0.84)	1.19 (1.30)	0.78 (1.81)	37.15	0.25 (0.87)	1.40 (1.38)	0.80 (1.14)	0.81 (1.84)	37.20
3.	*Beauveria bassiana* 1.15% WP @ 0.2%	2g	0.20 (0.84)	0.42 (0.96)	1.40 (1.38)	0.67 (1.78)	37.54	0.17 (0.82)	0.40 (0.95)	0.80 (1.14)	0.45 (1.70)	40.97	0.22 (0.85)	0.80 (1.14)	1.19 (1.30)	0.73 (1.81)	38.22
4.	*Datura* (*Datura stramonium* L.), leaf extract @ 5%	50ml	0.29 (0.89)	0.38 (0.94)	2.18 (1.64)	0.95 (1.86)	34.73	0.22 (0.85)	1.19 (1.30)	0.80 (1.14)	0.73 (1.72)	40.27	0.29 (0.89)	1.81 (1.52)	1.19 (1.30)	1.09 (1.93)	34.12
5.	*Lantana* (*Lantana camera* L.), leaf extract @ 5%	50ml	1.40 (1.38)	2.19 (1.64)	2.18 (1.64)	1.92 (2.21)	22.45	1.25 (1.32)	1.99 (1.58)	1.81 (1.52)	1.68 (2.13)	26.04	1.38 (1.37)	2.81 (1.82)	1.21 (1.31)	1.80 (2.16)	26.27
6.	*Aak* (*Calotropis gigantea* L.), leaf extract @ 5%	50ml	1.81 (1.52)	2.29 (1.67)	2.18 (1.64)	2.09 (2.26)	20.70	1.34 (1.36)	2.19 (1.64)	1.81 (1.52)	1.78 (2.16)	25.00	1.52 (1.42)	3.19 (1.92)	1.40 (1.38)	2.03 (2.23)	23.89
7.	Tobacco (*Nicotiana tabacum* L.), leaf extract @ 5%	50ml	0.40 (0.95)	1.19 (1.30)	1.99 (1.58)	1.19 (1.96)	31.22	0.32 (0.91)	1.14 (1.28)	1.60 (1.45)	1.02 (1.91)	33.38	0.40 (0.95)	2.19 (1.64)	1.19 (1.30)	1.26 (1.99)	32.08
8.	Untreated (Control)	-	3.58 (2.02)	4.70 (2.28)	5.35 (2.42)	4.54 (2.85)	-	3.91 (2.10)	4.74 (2.29)	5.40 (2.43)	4.68 (2.88)	-	4.36 (2.21)	4.84 (2.31)	5.55 (2.46)	4.92 (2.93)	-
SE (m) ±			0.173	0.262	0.141	0.070		0.175	0.262	0.230	0.056		0.170	0.230	0.230	0.082	
SE (d)			0.244	0.371	0.199	0.098		0.297	0.371	0.326	0.080		0.240	0.326	0.326	0.116	
C.D. at 5%			0.526	0.796	0.429	0.213		0.532	0.796	0.699	0.173		0.517	0.699	0.699	0.252	

Figures in parenthesis are √x+0.5 transformed value.

Table 3: Effect of different bio-pesticides on the larval population of diamondback moth on cabbage after 3rd, 7th and 14th DAS during 2020-21

S.N.	Treatments	Dose gm or ml/ ha	Larval population per plant														
			3 Days after spray (DAS)					7 Days after spray (DAS)					14 Days after spray (DAS)				
			1st	2nd	3rd	Mean	PROC	1st	2nd	3rd	Mean	PROC	1st	2nd	3rd	Mean	PROC
1.	*Bacillus thuringiensis* var. *kurstaki* (Dipel 8 L) @ 0.2%	2 ml	0.15 (0.81)	0.44 (0.97)	1.26 (1.33)	0.61 (1.76)	39.51	0.12 (0.79)	0.40 (0.95)	0.86 (1.17)	0.46 (1.70)	41.37	0.22 (0.85)	0.64 (1.07)	0.64 (1.07)	0.50 (1.72)	42.08
2.	Nimbicidine 0.15% EC (Azardirachtin 1500 ppm) @ 0.3%	3 ml	0.20 (0.84)	0.40 (0.95)	1.66 (1.47)	0.75 (1.80)	38.14	0.17 (0.82)	0.25 (0.87)	1.24 (1.32)	0.55 (1.73)	40.34	0.31 (0.90)	1.46 (1.40)	0.86 (1.17)	0.87 (1.86)	37.38
3.	*Beauveria bassiana* 1.15% WP @ 0.2%	2 gm	0.17 (0.82)	0.46 (0.98)	1.46 (1.40)	0.69 (1.79)	38.48	0.15 (0.81)	0.44 (0.97)	0.84 (1.16)	0.47 (1.71)	41.03	0.25 (0.87)	0.86 (1.17)	1.24 (1.32)	0.78 (1.83)	38.39
4.	*Datura* (*Datura stramonium* L.), leaf extract @ 5%	50 ml	0.25 (0.87)	0.40 (0.95)	2.28 (1.67)	0.97 (1.87)	35.73	0.20 (0.84)	0.29 (0.89)	0.89 (1.18)	0.46 (1.70)	41.37	0.36 (0.93)	1.87 (1.54)	1.26 (1.33)	1.16 (1.96)	34.00
5.	*Lantana* (*Lantana camera* L.), leaf extract @ 5%	50 ml	1.32 (1.35)	2.25 (1.66)	2.25 (1.66)	1.94 (2.21)	24.05	0.32 (0.35)	2.06 (1.60)	1.84 (1.53)	1.74 (2.03)	30.00	1.46 (1.40)	2.88 (1.84)	1.29 (1.34)	1.87 (2.18)	26.59
6.	*Aak* (*Calotropis gigantea* L.), leaf extract @ 5%	50 ml	1.43 (1.39)	2.35 (1.69)	2.25 (1.66)	2.01 (2.23)	23.36	1.32 (1.35)	2.22 (1.65)	1.87 (1.54)	1.80 (2.17)	25.17	1.57 (1.44)	3.38 (1.97)	1.46 (1.40)	2.13 (2.25)	24.24
7.	Tobacco (*Nicotiana tabacum* L.), leaf extract @ 5%	50 ml	0.34 (0.92)	1.21 (1.31)	2.06 (1.60)	1.20 (1.96)	32.64	0.29 (0.89)	1.19 (1.30)	1.66 (1.47)	1.04 (1.92)	33.79	0.44 (0.97)	2.28 (1.67)	1.26 (1.33)	1.32 (2.00)	32.65
8.	Untreated (Control)	-	4.25 (2.18)	4.74 (2.29)	5.40 (2.43)	4.79 (2.91)	-	4.07 (2.14)	4.79 (2.30)	5.50 (2.45)	4.78 (2.90)	-	4.51 (2.24)	4.97 (2.34)	5.65 (2.48)	5.04 (2.97)	-
SE (m) ±			0.191	0.265	0.148	0.070		0.234	0.263	0.234	0.065		0.179	0.238	0.236	0.082	
SE (d)			0.270	0.375	0.209	0.100		0.331	0.373	0.331	0.091		0.254	0.336	0.334	0.116	
C.D. at 5%			0.579	0.805	0.451	0.216		0.712	0.799	0.711	0.198		0.544	0.721	0.717	0.252	

Figures in parenthesis are √x+0.5 transformed value.

Table 4: Effect of different bio-pesticides on the larval population of diamondback moth on cabbage after 3rd, 7th and 14th DAS in both years during 2019-20 and 2020-21 (Pooled data)

S. N.	Treatments	Dose gm or ml/ ha	Larval population per plant															
			3 Days after spray (DAS)						7 Days after spray (DAS)						14 Days after spray (DAS)			
			Mean			PROC			Mean			PROC			Mean			PROC		
			2019-20	2020-21	Over all Mean	2019-20	2020-21	Mean PROC	2019-20	2020-21	Over all Mean	2019-20	2020-21	Mean PROC	2019-20	2020-21	Over all Mean	2019-20	2020-21	Mean PROC
1.	*Bacillus thuringiensis* var. *kurstaki* (Dipel 8 L) @ 0.2%	2 ml	0.59 (1.75)	0.61 (1.76)	0.60 (1.77)	38.59	39.51	39.05	0.43 (1.69)	0.46 (1.70)	0.44 (1.70)	41.31	41.37	41.34	0.46 (1.71)	0.50 (1.72)	0.48 (1.72)	41.63	42.08	41.85
2.	Nimbicidine 0.15% EC (Azardirachtin 1500 ppm) @ 0.3%	3 ml	0.72 (1.79)	0.75 (1.80)	0.73 (1.82)	37.19	38.14	37.66	0.78 (1.72)	0.55 (1.73)	0.66 (1.79)	37.15	40.34	38.74	0.81 (1.84)	0.87 (1.86)	0.84 (1.86)	37.20	37.38	37.29
3.	*Beauveria bassiana* 1.15% WP @ 0.2%	2 gm	0.67 (1.78)	0.69 (1.79)	0.68 (1.79)	37.54	38.48	38.01	0.45 (1.70)	0.47 (1.71)	0.46 (1.71)	40.97	41.03	41.00	0.73 (1.81)	0.78 (1.83)	0.75 (1.83)	38.22	38.39	38.30
4.	*Datura* (*Datura stramonium* L.), leaf extract @ 5%	50 ml	0.95 (1.86)	0.97 (1.87)	0.96 (1.90)	34.73	35.73	35.23	0.73 (1.81)	0.46 (1.70)	0.59 (1.76)	40.27	41.37	40.82	1.09 (1.93)	1.16 (1.96)	1.12 (1.96)	34.12	34.00	34.06
5.	*Lantana* (*Lantana camera* L.), leaf extract @ 5%	50 ml	1.92 (2.21)	1.94 (2.21)	1.93 (2.21)	22.45	24.05	23.25	1.68 (2.13)	1.74 (2.03)	1.71 (2.15)	26.04	30.00	28.02	1.80 (2.16)	1.87 (2.18)	1.83 (2.18)	26.27	26.59	26.43
6.	*Aak* (*Calotropis gigantea* L.), leaf extract @ 5%	50 ml	2.09 (2.26)	2.01 (2.23)	2.05 (2.25)	20.70	23.36	22.03	1.78 (2.16)	1.80 (2.17)	1.79 (2.17)	25.00	25.17	25.08	2.03 (2.23)	2.13 (2.25)	2.08 (2.25)	23.89	24.24	24.06
7.	Tobacco (*Nicotiana tabacum* L.), leaf extract @ 5%	50 ml	1.19 (1.96)	1.20 (1.96)	1.19 (1.98)	31.22	32.64	31.93	1.02 (1.91)	1.04 (1.92)	1.03 (1.93)	33.38	33.79	33.58	1.26 (1.99)	1.32 (2.00)	1.29 (2.01)	32.08	32.65	32.36
8.	Untreated (Control)	-	4.54 (2.85)	4.79 (2.91)	4.75 (2.88)	-	-	-	4.68 (2.88)	4.78 (2.90)	4.73 (2.89)	-	-	-	4.92 (2.93)	5.04 (2.97)	4.98 (2.95)	-	-	-
SE (m) ±			0.070	0.070	0.010				0.056	0.065	0.026				0.082	0.082	0.002			
SE (d)			0.098	0.100	0.015				0.080	0.091	0.036				0.116	0.116	0.003			
C.D. at 5%			0.213	0.216	0.035				0.173	0.198	0.088				0.252	0.252	0.006			

Figures in parenthesis are √x+0.5 transformed value

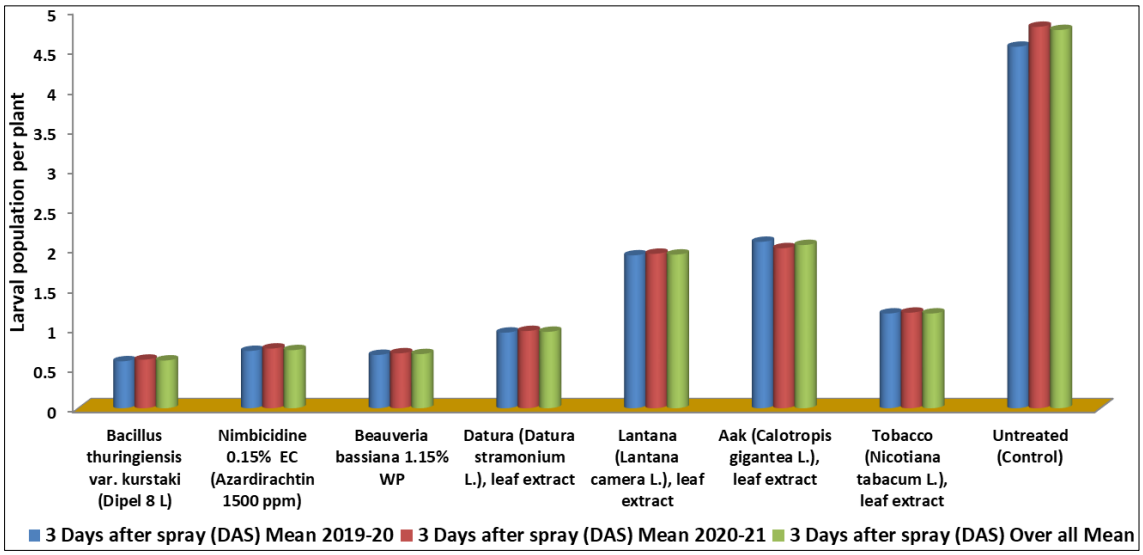

Fig 1: Effect of different bio-pesticides on the larval population of diamondback moth on cabbage after 3rd DAS in both years during 2019-20 and 2020-21 (Pooled data)

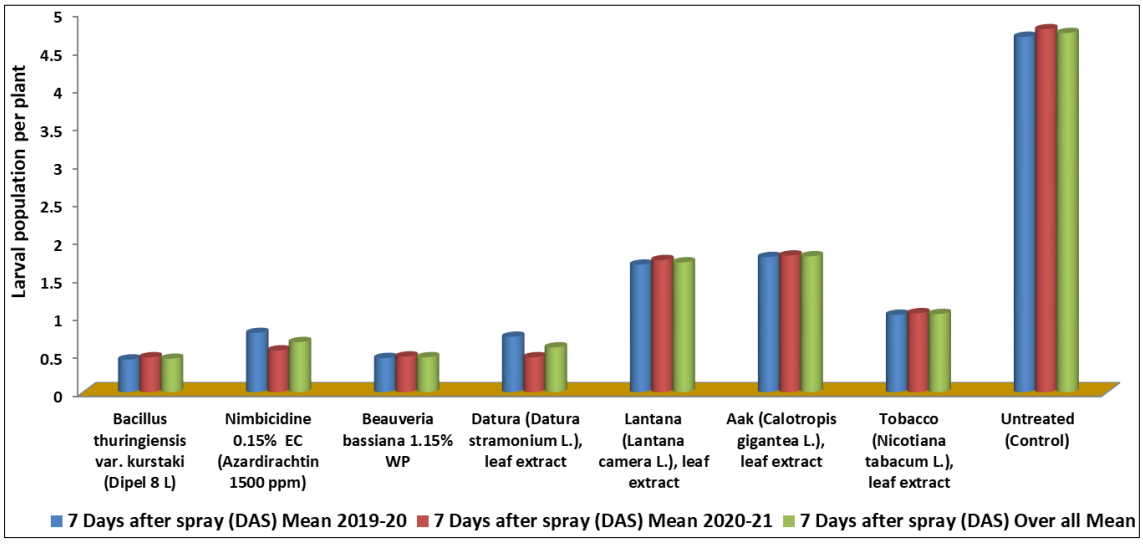

Fig 2: Effect of different bio-pesticides on the larval population of diamondback moth on cabbage after 7th DAS in both years during 2019-20 and 2020-21 (Pooled data)

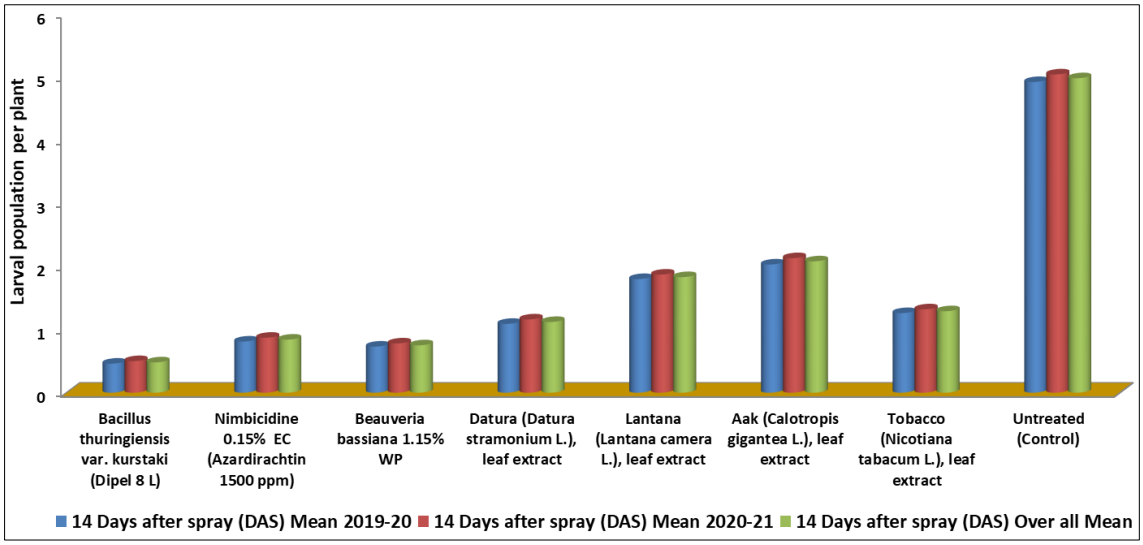

Fig 3: Effect of different bio-pesticides on the larval population of diamondback moth on cabbage after 14th DAS in both years during 2019-20 and 2020-21 (Pooled data)

Conclusion

The cabbage crops was found to be infested by diamondback moth, *P. xylostella* was observed most serious pest attacking the crop throughout the growth stage. It was first appeared on the crop in the 3rd and 2nd SMW and reached its peak during 9th SMW of February 2019-20 and 2020-21 respectively. Efficacy of natural products revealed that the *Bacillus thuringiensis* var. kurstaki (Dipel 8 L) @ 0.2% was proved best to check the *P. xylostella* population in both the years. Treatments effect on reducing larval population are indicating in descending order i.e. T_1 (*Bacillus thuringiensis* var. kurstaki (Dipel 8 L) @ 0.2%) > T_3 (*Beauveria bassiana* 1.15% WP @ 0.2%) > T_2 (Nimbicidine 0.15% EC (Azardirachtin 1500 ppm) @ 0.3%) > T_4 (*Datura* (*Datura stramonium* L.), leaf extract @ 5%) > T_7 (Tobacco (*Nicotiana tabacum* L.), leaf extract @ 5%) > T_5 (*Lantana* (*Lantana camera* L.), leaf extract @ 5%) > T_6 (*Aak* (*Calotropis gigantea* L.), leaf extract @ 5%) and untreated control. In this present study we concluded that the bio-pesticides are very useful in reducing pest population and cheapest source of insecticides to the farmers, no harmful effects on human as well as animal body. So we can easily employed in organic farming to get high quality chemical free products and export to foreign countries to get hard money. These all treatments are beneficial in reducing various diseases which caused by chemical insecticides. In future, the scope of organic products will increase due to the bed effects of chemical insecticides on the human health which is harmful to our nature. So the management of insects population in organic farming can be manages by using bio-pesticides which will be harmless to the animals and our ecosystem.

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References

1. Ali F, Tariq M, Shaheen FA, Mashwani ZR, Zainab T, Gulzar A. Toxicity of different plant extracts and green silver nanoparticles against *Plutella xylostella* (Lepidoptera: Plutellidae). Plant Protection. 2019;3(3):151-159.
2. Anonymous. Indian Horticultural Data Base, National Horticulture Board, Ministry of Agriculture, Govt. of India. 2019-20, 242.
3. Devi HD, Tayde AR. Comparative efficacy of bio-agents and botanicals on the management of diamondback moth (*Plutella xylostella* L.) on cabbage under Allahabad agroclimatic conditions. International Journal of Current Microbiology and Applied Sciences 2017;6(7):711-716.
4. Devjani P, Singh TK. Field density and biology of diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) on cauliflower in Manipur. Journal of Advanced Zoology.1999;20(1):53-55.
5. Fletcher TB. Some South Indian Insects, Superintendent Government Press, Madras, 1914, 565pp.
6. Jat GC, Swaminathan R, Yadav PC, Deshwal HL, Dotasara SK, Choudhary S, *et al*. Effect of natural enemies on the population dynamics of insect-pest of cabbage ecosystem. International Journal of Current Microbiology and Applied Sciences. 2017;6(6):696-708.
7. Khan HH, Kumar A, Naz H. Impact of different plant extracts and insecticides on the biology of *Pieris brassicae* (L.) on cabbage. The Pharma Innovation. 2017;6(12):164-168.
8. Krishnamoorthy A. Biological control of diamondback moth (*Plutella xylostella* L.), an Indian scenario with reference to past and future strategies. Proceedings of the International Symposium, Montpellier, France, Agricultural Research Centre for International Development (CIRAD), 2004, 204-211.
9. Mahla RS, Singh S, Chaudhary P. Management of diamondback moth, (*Plutella xylostella* L.) larvae by entomopathogenic fungus, *Metarhizium anisopliae*. Indian Journal of Entomology. 2005;67:342-344.
10. Samanta S, Sen R, Samanta A. Bio-efficacy of some bio-pesticides against major insect pests of cabbage. Journal of Entomology and Zoology Studies. 2020;8(3):1110-1115.
11. Sharma P, Kumawat KC, Lal J. Seasonal abundance of diamondback moth and natural enemies on cabbage. Journal of Entomology and Zoology Studies. 2017;5(3):176-179.
12. Singh G, Mann R, Singh D, Joia BS, Mahal MS. Current status of insecticide resistance in diamondback moth (*Plutella xylostella* Linnaeus). Journal of Insect Science. 2005;18(1):1-16.
13. Vanlaldiki H, Singh PM, Sarkar PK. Efficacy of eco-friendly insecticides on the management of diamondback moth (*Plutella xylostella* L.) on cabbage. International Journal of Life Sciences. 2013;8(4):1225-1230.