Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(6): 484-488

Received: 07-09-2019
Accepted: 09-10-2019

P Bhagat
Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

A Kerketta
Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

YK Yadu
Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
P Bhagat
Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Evaluation of botanicals against diamondback moth, *Plutella xylostella* (Linn.) on cabbage (*Brassica oleracea* var. *capitata* L.) crop

P Bhagat, A Kerketta and YK Yadu

Abstract
Studies were conducted to evaluate the efficacy of different botanicals against the diamondback moth on cabbage at the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *rabi* season of years, 2015-16 and 2016-17 in variety "Golden Acre". Among which its order of effectiveness during first spray was observed as Azadirachtin (1.52 larvae/plant) > Chilly+ Garlic solution (1.53 larvae/plant) > Neem seed powder extract (1.66 larvae/plant) > Karanj seed powder extract (1.70 larvae/plant) > Karanj oil solution (1.77 larvae/plant) > Neem oil solution (1.80 larvae/plant) > Neem cake petrol extract (1.89 larvae/plant)> Mahua oil solution (1.93 larvae/plant) and highest per cent reduction over control after first spray was recorded in Azadirachtin (36.66%). With similar trend during second spray, lowest population of DBM larvae was recorded in Azadirachtin (1.21 larvae/plant) followed by Chilly+ Garlic solution (1.41 larvae/plant) and Neem seed powder extract (1.49 larvae/plant) and their order of per cent reduction over control for second spray was found highest in Azadirachtin (56.93%). Effect of Azadirachtin on yield of cabbage heads (202.12 q/ha) was found superior over rest of the treatments.

Keywords: Botanicals, cabbage, diamondback moth, yield

Introduction
Cruciferous vegetables have an important place among *rabi* crops grown in India. Cabbage, *Brassica oleracea* var. capitata (Linn.) is a popular vegetable that is grown in all the states of India and has appreciable nutritional and economic value. The major constraint in the production of cabbage is pest complex right from germination till harvest. About 51 insect pests have been reported on cruciferous crops throughout the world. Insect pests are a serious menace in the profitable cultivation of cabbage. Among all the insect pests that attack crucifer vegetable crops, *viz*., tobacco caterpillar, *Spodoptera litura* Fabricius;diamondback moth, *Plutella xylostella* Linnaeus; cabbage leaf webber, *Crocidolomia binotalis* Zeller; aphids, *Brevicornye brassicae* Linnaeus and *Lipaphis erysimi* Kalt; painted bug, *Bagrada cruciferum* Kirk.; and flea beetle, *Phyllotreta cruciferae* Goeze (Rao and Lal, 2005) [11]. Out of these, diamondback moth, *Plutella xylostella* (L.) is the most destructive cosmopolitan pest (Mahla *et al*., 2005 and Kumar *et al*., 2007) [7, 6].

In India, diamondback moth has national importance on cabbage as it causes 50-80% annual loss in the marketable yield (Devjani and Singh, 1999 and Ayalew, 2006) [3, 1]. Krishnamoorthy (2002) also reported 52% loss in yield due to the attack of diamondback moth. Since cabbage is a highly remunerative, intensive plant protection measures involving a number of insecticides are common. In spite of large scale and indiscriminate applications of insecticides, the pest has been found to occur in severe form in all cabbage growing areas. Excessive use of insecticides has led to insecticidal resistance development, pest resurgence, residue hazards in foods and overall environmental contaminations.

This has prompted the promotion of other DBM management alternatives such as botanicals, microbial insecticide and insect growth regulators (IGRs). For example, aqueous extract of neem seed powder (50 g/l) and Bt (0.5k g/ha) were earlier recommended for use on cabbage against pests (Gashawbeza *et al*., 2009) [4]. Botanical insecticides are not only effective against crop pests but remain safer to natural enemies (Patel *et al*., 2003) [10]. They have been in use for centuries by farmers in developing countries to control insect pests of both field crops and stored produce. Some of these plant species possess one or more useful properties such as repellence, anti-feeding, fast knock down, flushing action, biodegradability, broad-spectrum of

activity and ability to reduce insect resistance (Mochiah *et al*., 2011) [9]. Therefore this study was conducted to determine the influence of botanical insecticides against DBM on cabbage crop.

Materials and Methods

The experiment was carried out during *rabi* season of years, 2015-16 and 2016-17 in cabbage, variety "Golden Acre". The field study was conducted at the experimental area of Indira Gandhi Agricultural University, Raipur (C.G.). Seedlings were grown on raised seed bed of 10 m^2 and transplanted. When seedling reached third to fourth true leaf stage. Each plot had three ridges of four meter long and each ridges with one row of cabbage on each side. Ridges were spaced 60 cm apart. The spacing between plants was 45 cm. Spacing between plots and replications was 0.50 m and 1.00 m, respectively. The crop was irrigated twice per week for the first four weeks after transplanting and once weekly thereafter.

Plots were fertilized with diammonium phosphate (DAP) and urea at the rate of 200 and 100 kg/ha, respectively. The whole amount of DAP was applied just before transplanting, while urea was applied by splitting the total amount in two. Half of the 100 kg was applied one month after transplanting and the remaining half at the beginning of head formation stage. Other field management practices like weeding, cultivation and maintenance of ridges were carried out as needed. The field experiment was conducted with nine treatments (table1), replicated thrice in Randomized Block Design. The treatments were given at the rate of 15 days interval. Observations on number of DBM were recorded on randomly selected five plants /plot before spray and 1, 7 and 14 days after each spray.

Statistical Analysis

Data on population count were transformed into square root transformation $\sqrt{X} + 0.5$ as per the method developed by Poisson for statistical analysis. Data collected from field experiments were subjected to analysis of variance and means were separated by randomized block design (RBD) using MS office excel sheet and OPSTAT statistical package.

Table 1: Treatment details for botanicals evaluation

S. No.	Treatment	Dose
1.	Neem Seed Powder Extract (NSPE) 4%	40g/l
2.	Neem Cake Petrol Extract (NCPE) (5% Neem cake + 0.1% Petrol)	50g/l+ 1ml/l petrol
3.	Karanj Seed Powder Extract (KSPE) 2.5% and 2g detergent /litre of spray solution as emulsifier	25 ml/l
4.	Karanj oil 2% and Teepol @ 1ml/litre of solution as emulsifier	20 ml /l
5.	Neem based Azadirachtin (1500 ppm)	2 ml /l
6.	Neem oil 2% and Teepol @ 1ml/litre of solution as emulsifier	20 ml /l
7.	Chilly + Garlic and 0.1% soap (Stock solution)	10 ml /l
8.	Mahua Oil 2% and Teepol@ 1ml/ litre of solution as emulsifier	20 ml /l
9.	Control	

Results and Discussion

The field experiment was conducted during *rabi*, 2015-16 and 2016-17 to assess the bioefficacy of botanicals against diamondback moth population at different intervals. Total two sprays of botanicals were applied during both the years. The larval population was recorded from randomly selected five plants from each plot, one day before application of botanicals as pre treatment observation and after one day, seven days and fourteen days of spray as post treatment observations. Cabbage heads yield was recorded from each plot separately.

First spray

One day after application of botanicals, it was observed that all the treatments were found significantly superior to untreated control in reducing the larval population of diamondback moth however, significant difference existed among them (table 2). The minimum number of larval population in DBM observed in Chilly+ Garlic solution (1.57 larvae/plant) followed by Azadirachtin (1.63 larvae/plant). After seven days of botanicals application, the maximum reduction in larval population was observed in Azadirachtin (1.53 larvae/plant). However, it was at par with Chilly + Garlic solution (1.63 larvae/plant) and Neem seed powder extract (1.73 larvae/plant). Maximum number of larval population was observed in Mahua oil solution (1.97 larvae/plant). Similarly, all the botanical treatments were found significantly superior to untreated control even after fourteen days of application. The minimum larval population was recorded in Azadirachtin (1.40 larvae/plant) and Chilly+ Garlic solution (1.40 larvae/plant) followed by Neem seed powder extract (1.53 larvae/plant) and Karanj seed powder extract (1.63 larvae/plant). The minimum reduction in larval population was observed in Mahua oil solution (1.87 larvae /plant).

The order of effectiveness of botanicals on the basis of pooled mean reduction in diamondback moth larval population in first spray was found as Azadirachtin (1.52 larvae/plant) > Chilly+ Garlic solution (1.53 larvae/plant) > Neem seed powder extract (1.66 larvae/plant) > Karanj seed powder extract (1.75 larvae/plant) > Karanj oil solution (1.77 larvae/plant) > Neem oil solution (1.80 larvae/plant) > Neem cake petrol extract (1.89 larvae/plant)> Mahua oil solution (1.93 larvae/plant).

Similarly, the impact of botanical treatments on the infestation of DBM larvae was also assessed and its order of effectiveness were arranged on the basis of pooled per cent reduction over control for first spray as Azadirachtin (36.66%) > Chilly+ Garlic solution (36.25%) > Neem seed powder extract (30.83%) > Karanj seed powder extract (27.08%) > Karanj oil solution (26.25%) > Neem oil solution (25%)> Neem cake petrol extract (21.25%)> Mahua oil solution (19.58%).

Second spray

As depicted in table 3, one day after application of botanicals, it was observed that all the treatments were found significantly superior to untreated control in reducing the larval population of diamondback moth. However, significant difference existed among them. The lowest larval population was observed in Azadirachtin (1.20 larvae/plant) followed by Chilly+ Garlic solution (1.33 larvae/plant) then Neem seed powder extract, Karanj seed powder extract and Karanj oil solution (these three treatments had larval population of 1.40 larvae/plant) and all these five treatments were found at par

with each other. Next effective treatment was Neem oil solution (1.57 larvae/plant). Least efficacy was observed in both treatments, Mahua oil solution and Neem cake petrol extract with larval population of 1.60 larvae/plant.

After seven days of botanicals application, the maximum reduction in larval population was observed in Azadirachtin (1.20 larvae/plant) followed by Chilly+ Garlic solution (1.40 larvae/plant), however these both treatments are found at par with each other and significantly superior than other treatments.

All the botanical treatments were found significantly superior to untreated control even after fourteen days of application. The minimum larval population was recorded in Azadirachtin (1.23 larvae/plant) and found at par with Chilly+ Garlic solution (1.50 larvae/plant), Neem seed powder extract (1.60 larvae/plant), Karanj seed powder extract (1.67 larvae/plant), Karanj oil solution (1.73 larvae/plant), followed by Neem oil solution and Neem cake petrol extract (1.80 larvae/plant).The minimum reduction in larval population was observed in Mahua oil solution (1.93larvae/plant). These findings are partially related with works of Stanikzi and Thakur (2016) [13] who also reported that Neem Seed Kernal extract (39.195) was superior over Neem oil (39.705) among the botanicals against diamondback moth.

The order of effectiveness of botanical treatments on the basis of pooled mean reduction in diamondback moth larval population in second spray was found as Azadirachtin (1.21 larvae/plant) > Chilly+ Garlic solution (1.41 larvae/plant) > Neem seed powder extract (1.49 larvae/plant) > Karanj seed powder extract (1.53 larvae/plant) >Karanj oil solution(1.57 larvae/plant) > Neem oil solution (1.65 larvae/plant) > Neem cake petrol extract (1.69 larvae/plant)> Mahua oil solution (1.77 larvae/plant).

Similarly, the order of effectiveness of botanicals on the basis of pooled per cent reduction over control for second spray was found to be Azadirachtin (56.93%) > Chilly+ Garlic solution (49.82%) > Neem seed powder extract (46.12%) > Karanj seed powder extract (45.55%) > Karanj oil solution (44.12%) > Neem oil solution (41.28%)>Neem cake petrol extract (39.85%)> Mahua oil solution (37.01%). These findings are similar with works of Sewak *et al*. (2008) [12] who evaluated the efficacy of certain indigenous products along with three chemical insecticides and their combinations against the diamondback moth, *P. xylostella*. Amongst the indigenous products, extract of chilli + garlic 5 percent (54.31%) was reported at par with extract of NSKE (5%) and Tuan *et al.* (2014) [14] who revealed that garlic and chili combination solution effectively reduced cabbage insect pests. Begna1 and Damtew (2015) [2] sprayed four locally available botanicals for diamondback moth management among which, neem was the best treatment as it gave the highest yield.

Impact of botanicals application on cabbage yield

Table 4 represents the data on yield of cabbage heads recorded during years, 2015-16 and 2016-2017 after the botanicals spray. The mature cabbage heads were weighed at each time from different plots. The cumulative yield expressed in weight of harvested cabbage heads per plot as well as weight of all the three pickings from each plot.

The data recorded on the yield during *rabi* seasons of both the years were pooled together for better assessment of the performance of different treatments over untreated control.The pooled data on yield clearly demonstrated that maximum (21.83 kg/plot / 202.12 q/ha) and minimum (11.67 kg/plot / 108.06 q/ha) yield harvested from plots treated with Azadirachtin and Mahua oil solution, respectively. This data also showed that effect of Azadirachtin (21.83 kg/plot / 202.12q/ha) on yield was found superior over rest of the treatments and followed by the effect of Chilly+ Garlic solution > Neem seed powder extract > Karanj seed powder extract > Karanj oil solution > Neem oil solution > Neem cake petrol extract > Mahua oil solution with 19.83 > 17.83 > 16.50 > 16.17 > 13.83 > 12.00 > 11.67 kg/plot / 183.61 > 165.10 > 152.78 > 149.72 > 128.06 > 111.11 > 108.06 q/ha, respectively.

Conclusion

Result of field experiment conducted during *rabi*, 2015-16 to assess the bio-efficacy of botanicals against diamondback moth population evaluated that Azadirachtin recorded the minimum population (1.60 and 1.38 larvae/plant) followed by Chilly + Garlic (1.62 and 1.56 larvae/plant) and Neem seed powder extract (1.73 and 1.62 larvae/plant) after first and second spray, respectively.

Similar trend was followed in year 2016-17, where minimum population of DBM larvae noticed in Azadirachtin and Chilly + Garlic (1.44 larvae/plant) followed by Neem seed powder extract (1.60 larvae/plant), after first spray whereas Azadirachtin recorded minimum population of 1.04 larvae /plant followed by Chilly + Garlic solution (1.27 larvae /plant) and Neem seed powder extract (1.36 larvae/plant) after second spray.

The order of effectiveness of botanicals on the basis of pooled mean reduction in diamondback moth larval population in first spray was found as Azadirachtin (1.52 larvae/plant) > Chilly+ Garlic solution (1.53 larvae/plant) > Neem seed powder extract (1.66 larvae/plant) > Karanj seed powder extract (1.75 larvae/plant) > Karanj oil solution(1.77 larvae/plant) > Neem oil solution (1.80 larvae/plant) > Neem cake petrol extract (1.89 larvae/plant)> Mahua oil solution (1.93 larvae/plant). Similarly, its order of effectiveness were arranged on the basis of pooled per cent reduction over control for first spray as Azadirachtin (36.66%) > Chilly+ Garlic solution (36.25%) > Neem seed powder extract (30.83%) > Karanj seed powder extract (27.08%) > Karanj oil solution (26.25%) > Neem oil solution (25%) > Neem cake petrol extract (21.25%) > Mahua oil solution (19.58%).

Pooled mean reduction in diamondback moth larval population in second spray was found as Azadirachtin (1.21 larvae/plant) > Chilly + Garlic solution (1.41 larvae/plant) > Neem seed powder extract (1.49 larvae /plant). Similarly, the order of effectiveness of botanicals on the basis of pooled per cent reduction over control for second spray was found as Azadirachtin (56.93%) > Chilly+ Garlic solution (49.82%) > Neem seed powder extract (46.12%).

The performance of Azadirachtin (21.67and 22.0 kg/plot) on yield is followed by Chilly+ Garlic solution > Neem seed powder extract with 19.66 and 20.0 > 17.34 and 18.33 kg/plot during year 2015-16 and 2016-17, respectively.

Acknowledgement

Authors are thankful to Dean (Agriculture), Indira Gandhi Krishi Viswavidyalaya, Raipur (C.G.) for providing the necessary facilities and support for carrying out the study successfully.

Table 2: Effect of botanicals on diamondback moth, *Plutella xylostella* (Linn.) management in cabbage during both years (2015-16 and 2016-17) after first spray (pooled)

Treatment		*Mean larval population of *P. xylostella* per plant									Mean of pooled values	Per cent reduction over control
		Days after treatment										
		1st day after spray		Pooled value	7th day after spray		Pooled value	14th day after spray		Pooled value		
		2015-16	2016-17		2015-16	2016-17		2015-16	2016-17			
T_1	Neem seed powder extract (PNSPE) 4%	1.73 (1.65)	1.73 (1.65)	1.73 (1.65)	1.80 (1.67)	1.67 (1.63)	1.73 (1.65)	1.67 (1.63)	1.40 (1.54)	1.53 (1.59)	1.66 (1.63)	30.83
T_2	Neem Cake Petrol Extract (NCPE) (5% Neem cake +0.1% Petrol)	1.93 (1.71)	1.93 (1.71)	1.93 (1.71)	2.00 (1.73)	1.87 (1.69)	1.93 (1.71)	1.93 (1.71)	1.73 (1.65)	1.83 (1.68)	1.89 (1.7)	21.25
T_3	Karanj seed powder extract and 2% detergent as liquid emulsifier	1.80 (1.67)	1.87 (1.69)	1.83 (1.68)	1.87 (1.69)	1.73 (1.65)	1.80 (1.67)	1.73 (1.65)	1.53 (1.58)	1.63 (1.62)	1.75 (1.65)	27.08
T_4	Karanj oil and Teepol @ 1ml/litre of solution as emulsifier	1.87 (1.69)	1.80 (1.67)	1.83 (1.68)	1.87 (1.69)	1.67 (1.63)	1.77 (1.66)	1.80 (1.67)	1.67 (1.63)	1.73 (1.65)	1.77 (1.66)	26.25
T_5	Azadirachtin (1500 ppm)	1.67 (1.63)	1.60 (1.61)	1.63 (1.62)	1.60 (1.61)	1.47 (1.56)	1.53 (1.59)	1.53 (1.59)	1.27 (1.50)	1.40 (1.54)	1.52 (1.58)	36.66
T_6	Neem oil 2% +Teepol@1ml/litre of solution as emulsifier	1.87 (1.69)	1.73 (1.65)	1.80 (1.67)	1.93 (1.71)	1.80 (1.67)	1.87 (1.69)	1.87 (1.69)	1.60 (1.60)	1.73 (1.65)	1.8 (1.67)	25.00
T_7	Chilly + Garlic and 0.1% soap (Stock solution)	1.60 (1.61)	1.53 (1.58)	1.57 (1.60)	1.73 (1.65)	1.53 (1.59)	1.63 (1.62)	1.53 (1.59)	1.27 (1.50)	1.40 (1.54)	1.53 (1.58)	36.25
T_8	Mahua Oil and Teepol@ 1ml /litre of solution as emulsifier	2.00 (1.73)	1.93 (1.71)	1.97 (1.72)	2.07 (1.75)	1.87 (1.69)	1.97 (1.72)	2.00 (1.73)	1.73 (1.64)	1.87 (1.69)	1.93 (1.71)	19.58
T_9	Control	1.73 (1.65)	2.20 (1.78)	2.27 (1.80)	2.40 (1.84)	2.40 (1.84)	2.40 (1.84)	2.53 (1.88)	2.53 (1.88)	2.53 (1.88)	2.4 (1.84)	
	S. Em. ±	0.02	0.03	0.02	0.01	0.04	0.02	0.02	0.06	0.03		
	CD at 5%	0.08	0.09	0.06	0.05	0.13	0.06	0.08	0.18	0.09		

*Mean of three replications, Figures in parentheses are square root transformed values

Table 3: Effect of botanicals on diamondback moth, *Plutella xylostella* (Linn.) management in cabbage during both years (2015-16 and 2016-17) after second spray (pooled)

Treatment		*Mean larval population of *P. xylostella* per plant									Mean of pooled values	Per cent reduction over control
		Days after treatment										
		1st day after spray		Pooled value	7th day after spray		pooled value	14th day after spray		Pooled value		
		2015-16	2016-17		2015-16	2016-17		2015-16	2016-17			
T_1	Neem seed powder extract (PNSPE) 4%	1.53 (1.58)	1.27 (1.50)	1.40 (1.54)	1.60 (1.61)	1.33 (1.52)	1.47 (1.57)	1.73 (1.65)	1.47 (1.56)	1.60 (1.61)	1.49 (1.57)	46.97
T_2	Neem Cake Petrol Extract (NCPE) (5% Neem cake +0.1% Petrol)	1.73 (1.65)	1.47 (1.56)	1.60 (1.61)	1.80 (1.67)	1.53 (1.58)	1.67 (1.63)	1.93 (1.71)	1.67 (1.63)	1.80 (1.67)	1.69 (1.63)	39.85
T_3	Karanj seed powder extract and 2% detergent as liquid emulsifier	1.53 (1.59)	1.27 (1.50)	1.40 (1.54)	1.67 (1.63)	1.40 (1.54)	1.53 (1.59)	1.80 (1.67)	1.53 (1.58)	1.67 (1.63)	1.53 (1.58)	45.55
T_4	Karanj oil and Teepol @ 1ml/litre of solution as emulsifier	1.53 (1.59)	1.27 (1.50)	1.40 (1.54)	1.73 (1.65)	1.47 (1.56)	1.60 (1.61)	1.87 (1.68)	1.60 (1.59)	1.73 (1.64)	1.57 (1.59	44.12
T_5	Azadirachtin (1500 ppm)	1.27 (1.50)	1.13 (1.45)	1.20 (1.48)	1.33 (1.52)	1.07 (1.43)	1.20 (1.48)	1.53 (1.59)	0.93 (1.38)	1.23 (1.49)	1.21 (1.48)	56.93
T_6	Neem oil 2% +Teepol@1ml/litre of solution as emulsifier	1.73 (1.65)	1.40 (1.54)	1.57 (1.60)	1.73 (1.65)	1.47 (1.56)	1.60 (1.61)	1.93 (1.71)	1.67 (1.62)	1.80 (1.67)	1.65 (1.62)	41.28
T_7	Chilly + Garlic and 0.1% soap (Stock solution)	1.47 (1.56)	1.20 (1.48)	1.33 (1.52)	1.53 (1.59)	1.27 (1.50)	1.40 (1.54)	1.67 (1.63)	1.33 (1.52)	1.50 (1.58)	1.41 (1.54)	49.82
T_8	Mahua Oil and Teepol@ 1ml /litre of solution as emulsifier	1.73 (1.65)	1.47 (1.56)	1.60 (1.61)	1.93 (1.71)	1.67 (1.63)	1.80 (1.67)	2.07 (1.75)	1.80 (1.66)	1.93 (1.71)	1.77 (1.66)	37.01
T_9	Control	2.73 (1.93)	2.73 (1.93)	2.73 (1.93)	2.80 (1.94)	2.80 (1.94)	2.80 (1.94)	2.93 (1.98)	2.87 (1.96)	2.90 (1.97)	2.81 (1.94)	
	S. Em. ±	0.03	0.05	0.03	0.02	0.06	0.028	0.04	0.092	0.055		
	CD at 5%	0.11	0.15	0.09	0.08	0.19	0.08	0.12	0.27	0.16		

*Mean of three replications, Figures in parenthesis are square root transformed values

Table 4: Impact of botanical treatments on cabbage yield during *rabi* season of 2015-2016 and 2016-2017 (pooled)

Treatments		Dose	*Mean weight of harvested heads (kg/plot)			Total yield (kg/plot)	Overall mean yield of cabbage q/ha
			1st pick	2nd pick	3rd pick		
T_1	Neem seed powder extract (PNSPE) 4%	40g/l	4.83	8.17	4.83	17.83	165.10
T_2	Neem Cake Petrol Extract (NCPE) (5% Neem cake +0.1% Petrol)	50g/l+ 1ml/l petrol	3.00	5.33	3.67	12.00	111.11
T_3	Karanj seed powder extract and 2% detergent as liquid emulsifier	25 ml /l	4.50	6.83	5.17	16.50	152.78
T_4	Karanj oil and Teepol @ 1ml/litre of solution as emulsifier	20 ml /l	3.83	7.67	4.67	16.17	149.72
T_5	Azadirachtin (1500 ppm)	2 ml /l	5.67	9.50	6.67	21.83	202.12
T_6	Neem oil 2%	20 ml /l	4.67	4.83	4.33	13.83	128.06
T_7	Chilly + Garlic and 0.1% soap (Stock solution)	10 ml /l	5.50	8.33	6.00	19.83	183.61
T_8	Mahua Oil and Teepol@ 1ml /litre of solution as emulsifier	20 ml /l	2.83	5.50	3.33	11.67	108.06
T_9	Control	-	2.67	4.67	2.67	10.00	92.60
S. Em. ±			0.12	0.10	0.08		
CD at 5%			0.39	0.30	0.21		

*Mean of three replications

References

1. Ayalew G. Comparison of yield loss on cabbage from diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) using two insecticides. Crop Protection. 2006; 25:915-919.
2. Begna F, Damtew T. Evaluation of four botanical insecticides against diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) on head cabbage in the central rift valley of Ethiopia. Sky Journal of Agricultural Research. 2015; 4(5):97-105.
3. Devjani P, Singh TK. Field density and biology of diamondback moth, *Plutella xylostella* L. (Lepidoptera: Yponomeutidae) on cauliflower in Manipur. Journal of Advanced Zoology. 1999; 20(1):53-55.
4. Gashawbeze A, Bayeh M, Mulugeta N, Yeshitila M, Lidet S, Ahmed Ibrahim *et al*. Review of research on insect and mite pests of vegetable crops in Ethiopia. Cited in: Abraham Tadesse (ed.). Increasing Crop Production through Improved Plant Protection-Vol. II. Plant Protection Society of Ethiopia (PPSE). PPSE and EIAR, Addis Ababa, Ethiopia. 2009, 47-67.
5. Krishnamoorthy A. Biological control of diamondback moth, *Plutella xylostella* (Linn.) and Indian scenario with reference to past and future strategies. In: Kirk, A.A., Bordat, D. (Eds). Proceedings of the International Symposium, Montpallier, France, CIRAD, 2004, 204-211.
6. Kumar P, Prasad CS, Tiwari GN. Population intensity of insect pests of cabbage in relation to weather parameters. Annals of Plant Protection Sciences. 2007; 15:245-246.
7. 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.
8. Maison BL. Insect pest of crucifers and their control. Annual Review of Entomology. 1965; 10:233-256.
9. Mochiah MB, Banful B, Fening K, Amoabeng B, OffeiBonsu K, Ekyem S *et al*. Botanicals for the Management of Insect Pests in Organic Vegetable Production. J of Entomol. and Nematol. 2011; 3:85-97, Available Online at Http://Www.Academicjournals.Org/Jen.
10. Patel PS, Shukla NP, Patel GM. Enhancing Insecticidal Properties of Cow Urine against Sucking Pests of Cotton. In: Proceedings of the National Symposium on Front erier Areas of Entomological Research, 2003; 5-7:385.
11. Rao SRK, Lal OP. Seasonal incidence of mustard aphid, *Lipaphis erysimi* (Kalt) and diamondback moth, *Plutella xylostella* (L.) on cabbage. Journal of Insect Science. 2005; 18(2):106-110.
12. Sewak S, Ahmad S, Mishra MS. Bioefficacy of indigenous products and their combinations against diamondback moth, *Plutella xylostella* (L.). Pestology. 2008; 32(6):23-27.
13. Stanikzi R, Thakur S. Efficacy of chemical insecticides and botanicals in the management of diamondback moth (*Plutella xylostella*) in cabbage (*Brassica oleracea* var. *capitata* L.). International Journal of Multidisciplinary Research and Development. 2016; 3(6):101-104.
14. Tuan NM, Anh BL, Hoang BN. Efficacy of garlic and chilli combination solution on cabbage insect pests and crop growth in Vietnam. International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering. 2014; 8(10):1151-1154.