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Comparative Efficacy of Synthetic Insecticides and Botanical Extracts against Diamondback Moth (Plutella Xylostella) (Lepidoptera: Plutellidae) in Cauliflower

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Abstract:

Experiments were conducted to investigate the prevalence of Diamondback moth (Plutella xylostella) and to compare the efficacy of synthetic insecticides (Emamectin benzoate, Lufenuron and Lannate) and botanical extracts (Bakain & Neem) for the management of Plutella xylostella larvae in cauliflower during the year, 2012 at Agricultural Research Station Baffa Mansehra, Khyber Pakhtunkhwa. Completely Randomized Design (CRD) was used for laboratory bioassays while the field experiments were carried out in Randomized Complete Block Design (RCBD). Leaf dip bioassays were conducted to compare the relative effectiveness of the insecticides against larvae after 12, 24, 48 and 72 hours in laboratory. The results revealed that

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Emamectin benzoate proved to be the best one with significantly higher level of morality 90.8 % followed by Lannate (75.8 %), Lufenuron (60.0%), Neem (50.6 %), Bakain (36.8 %) as compared to that of control (14.8 %) after 72 hours. The results regarding field experiment showed that all the treatments were significantly different but Emamectin benzoate provided excellent control of larvae and kept larval densities at relatively low level with the mean number of 3.0 larvae plant^{-1} followed by Lannate (4.1), Lufenuron (5.2), Neem (6.0) and Bakain (6.8) larvae plant^{-1}, respectively. The effect of treatments was proved reciprocal to the effect on pest population. Hence, Emamectin benzoate treated plots gave the highest yield (30,533) Kg ha^{-1}followed by Lannate (25,266), Lufenuron (16,933), Neem (12,733) and Bakain (9,333) compared with the control plots (5,333) Kg ha^{-1}. Thus it could be concluded from the results that there is potential to use Emamectin benzoate in combination with the botanical insecticides to maintain the population of this pest below damage level.

Key words: Diamondback moth; *Plutella xylostella*; Plant extracts; Bakain; Lufenuron; chemical control.

Introduction

Diamondback moth (DBM), *Plutella xylostella* (Lepidoptera: Plutellidae) is a serious pest and has a great economic importance worldwide (You and Wei, 2007). In its initial attack, the pest firstly feeds on leaves and later on enters inside the curd thus causing qualitative and quantitative losses to this crop. The damage is caused by its larvae which skeletonizes the foliage part of the host plant and renders it unfit for consumption (Sanaverappanavar and Virktamath, 1997). The pest infests the plant at all the growth stages causing defoliation, leaf curling and stunting of the plant. In addition to crop losses, the annual management costs for controlling this pest were estimated to be more than US$1.0 billion globally (Grzywaez *et al,* 2010).

Plutella xylostella has become most difficult insect in the world to control, primarly because of significant resistance to almost every class of insecticide applied in field. Most effort has been devoted to find alternative control measures for this pest because of the negative impact of pesticides and the problems encountered in controlling diamondback moth populations. Alternative sources of potentially suitable insecticides include botanical insecticides, antifeedants and insect growth regulators of their natural origin having non-neurotoxic modes of action, and low environmental persistence. Botanical extracts can change the behaviour and development of the herbivorous insects. (Isman, 2006).The current studies were therefore undertaken to study the comparative efficacy of botanical extracts and synthetic insecticide against *Plutella xylostella* under laboratory and field conditions in cauliflower at Mansehra.

Materials and Methods

The research work including laboratory and field experiments were conducted for the management of Diamondback moth (*Plutella xylostella*) in cauliflower during year 2012 at Agricultural Research Station, Baffa Mansehra, Khyber Pakhtunkhwa. The synthetic insecticides viz; Emamectin Benzoate, Lufenuron, and Lannate were obtained from local authorized dealers. The plant material for botanical extracts of Neem (*Azadirachta indica*) and Bakain (*Melia azedarach* L) were collected from Baffa area.

Laboratory Test

The laboratory experiment was conducted using completely randomized design. Diamondback moth larvae were collected from the infested plants in the field and left to starve for five hours. Fresh uninfested leaves of cauliflower were collected from untreated field and washed with tap water. Then these leaves were treated with their respective insecticide dose by dip method for ten second and allowed to dry on blotting paper at room temperature for ten minutes. These fresh uninfested treated leaves were placed in Petri dishes. Moistened filter paper cut was placed beneath the leaves to avoid desiccation of the leaf disc in the Petri dishes. The starved larvae (15/ Petri dish) were allowed to feed on them. The experiment was repeated 5 times. The experiment was carried out at 35 ±1 degree centigrade and 65±5% relative humidity (Tufail and Ansari, 2010).

Data collection

Larval mortality was recorded after feeding the starving larvae on the treated leaves. The *Plutella xylostella* larval were examined for mortality, 12, 24, 36 and 72 hours after release. Larvae were considered dead if they failed to respond to stimulation by touch.

Field Test

Cauliflower nursery was grown on 25th of June 2012, at raised nursery beds using the cauliflower variety ”Taxila”. This variety is generally grown in the area and is mostly acceptable to the farming communities of the area. The seedlings were transplanted in the field on 13th of July, already prepared for the purpose. The plant to plant and row to row distances were kept at 30cm and 75cm, respectively. The experiment comprised of six treatments and each subplot was allotted 40 plants grown in four rows. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of each subplot was 15m^2 where as total experimental area was 270m^2. Upon the appearance of the pest, recommended dose of each insecticide, and extract, was applied separately by compressed air sprayer. Data were recorded from the 5 randomly selected plants plot^{-1}. The numbers of *P. xylostella* larvae were counted on three leaves, at the top, middle and lower regions of the selected plants. The observations were repeated at weekly intervals till maturity of the crop.

Table-I: List of the synthetic insecticides and botanical extracts tested against Diamondback moth Plutella xylostella larvae in Brassica oleracea.

S.No.	Trade Name	Common Name	Chemical Group	Dose/10 L	Active Ingredient (g/l)
1.	Ematac	Emamectin benzoate	Avermectin	50 ml	19
2.	Match	Lufenuron	Acyl urea	200 ml	50
3.	Lennate	Methomyl	Organochloride	50 ml	40
4.	Bakain	*Melia azedarach*	Botanical insecticide	500 g	…….
5.	Neem	*Azadirachta Indica*	Botanical insecticide	500 g	…….

Data collection

The following parameters were studied for data collection.

Population Density

In order to study the population density of diamondback moth (*Plutella xylostella*) five different plants were randomly selected in two central row of each treatment. Numbers of larvae were counted on five randomly selected plants. The data were recorded 3 days and after spray and 7 day (weekly) after spray.

Yield

Yield data were recorded with each picking and was converted in kg ha^{-1}. Increase in percent yield over control was derived by using the following formula.

$$\% \text{ Increase in yield over control} = \frac{\text{Treatment yield} - \text{Control yield}}{\text{Treatment yield}} \times 100$$

Data Analysis

The data obtained were subjected to ANOVA for the interpretation of specific results by using the statistical package MStat-C. LSD test was applied at 5% level of significance ($P<0.05$) for separation of Means. (Steels and Torrie, 1980).

Results

Laboratory bioassay of Diamondback moth (Plutella xylostella)

Data regarding the laboratory bioassays is presented in (Table-II). Leaf dip bioassays were conducted to compare the relative effectiveness of Emamectin benzoate, Lufenuron, Lannate, Bakain and Neem against Diamondback moth (*Plutella xylostella*) larvae after 12, 24, 48 and 72 hours. The results are described below.

The results indicate that insecticides have significant effects ($F_{5, 20} = 3.85$, $p<0.0132$) on mortality of larvae as compared to the untreated (control) after 12 hours. Emamectin benzoate and Lannate treatments gave very rapid kill (6.6%) and (2.8%), respectively as compared with that of the control (0.00%). In case of botanical extracts Bakain and Neem did not affect larvae.

It is evident from the data (Table-II) that significant effect of insecticides ($F_{5, 20} = 14.49$, $p<0.0000$) was observed as compared to the control after 24 hours. Emamectin benzoate and Lannate treatments were effective and caused (30.8%) and (25.4%) mortality, respectively as compared to that of the control (1.4%). The botanical insecticide Bakain and Neem though efficacious, yet proved much slower in expressing their potency against the larvae.

Similarly results revealed significant effect of different insecticides after 48 hours ($F_{5, 20} = 72.01$, $p<0.0000$). Emamectin benzoate and Lannate treatments showed (63.8%) and (52.0%), mortality respectively as compared to that of the control (6.6%). It is also evident that Lufenuron and Neem treatments exhibited equivalent level of mortality after 48 hours (34.4 %) and (30.6%) respectively but Bakain was least effective with (21.4%).

Table-II: Toxicity of different insecticides against Plutella xylostella larvae under laboratory condition.

S. No.	Treatments	Mortality (%)			
		12 hours	24 hours	48 hours	72 hours
1	Emamectin benzoate	6.6 a*	30.8 a	63.8 a	90.8 a
2	Lufenuron	0.0 b	10.6 b	34.4 c	60.0 c
3	Lannate	2.8 ab	25.4 a	52.0 b	75.8 b
4	Bakain	0.0 b	8.0 bc	21.4 d	36.8 e
5	Neem	0.0 b	10.6 b	30.6 c	50.6 d
6	Control	0.0 b	1.4 c	6.6 e	14.8 f
LSD Values		4.0713	8.6902	7.1744	9.1342

*Means followed by same letter within each column are not significantly different from each other at 5 % level of probability.

The data showed significant toxicity of insecticides after 72 hours ($F_{5, 20} = 82.36$, $p<0.0000$). Among all the tested insecticide Emamectin benzoate and Lannate appeared to be most virulent with mortality of 90.8% and 75.8% respectively, followed by Lufenuron (60 %), Neem (50.6%) and Bakain (36.8%) as compared to that of the control (14.8%).

Results revealed that Emamectin benzoate treatment gave the best control among all the treatments. Overall, all the insecticides tested in this study were able to exert a significant reduction in the number of *P. xylostella* larvae as compared to control.

Efficacy of Synthetic Insecticide and Botanical Extracts against Diamondback Moth (Plutella xylostella) Larvae in Cauliflower.

The population density of Diamondback moth (*P. xylostella*) larvae increased on 21st of August 2012, and need special attention for the management. The recommended doses of synthetic insecticides (Emamectin benzoate, Lufenuron, and Lannate) and botanical extracts (Neem and Bakain) were applied on 22nd of August against larvae.

Data (Table-III) revealed that Emamectin benzoate appeared to be the most virulent to decrease the number of *Plutella Xylostella* with average number of (5.8 larvae $plant^{-1}$) followed by Lannate (7.4 larvae $plant^{-1}$), Lufenuron (8.5 larvae $plant^{-1}$), Neem (9.6 larvae $plant^{-1}$), Bakain (10.2 larvae $plant^{-1}$), and control (11.8 larvae $plant^{-1)}$ 3rd day after spray (25th of August) in ascending order ($F_{5, 10} = 59.55$, $p<0.0000$).

Similarly 7th day after spray (29th of August) data showed that larval population greatly declined ($F_{5, 10} = 74.81$, $p<0.0000$). Emamectin benzoate showing lowest population density of (4.6 larvae $plant^{-1}$) while population in other treatments was Lannate (6.2 larvae $plant^{-1}$), Lufenuron (7.4 larvae $plant^{-1}$), Neem (8.5 larvae $plant^{-1}$), Bakain (9.1 larvae $plant^{-1}$) and control (13.0 larvae $plant^{-1}$).

All the tested insecticides were applied for second time for further investigation on 30th of August. The data (Table-IV) revealed that larval population was affected by different treatments after 3rd day of spray (2nd of September) Emamectin benzoate proved most toxic ($F_{5, 10} = 250.98$, $p<0.0000$) which decreased the population to (3.8 larvae $plan^{-1}$). Pest number in other treatment was noted as Lannate (5.1 larvae plant^{-1}), Lufenuron (6.2 larvae plant^{-1}), Neem (6.7 larvae plant^{-1}), Bakain (7.7 larvae plant^{-1}) and control (16.4 larvae plant^{-1}).

Table III: Effect of insecticides on larval population density of Plutella xylostella under field condition during July- Sep 2012 at distric Mansehra.

S. No.	Treatments	1st Spray (No. larvae plants^{-1}		2nd Spray (No. larvae plants^{-1})		3rd Spray (No. larvae plants^{-1})	
		3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
1	Emamectin benzoate	5.8 e*	4.6 e	3.8 e*	2.4 d	0.9 d*	0.5 d
2	Lufenuron	8.5 c	7.4 c	6.2 c	4.5 bcd	3.2 c	1.8 c
3	Lannate	7.4 d	6.2 d	5.1 d	3.3 cd	1.8 d	0.7 d
4	Bakain	10.2 b	9.1 b	7.7 b	6.1 b	4.7 b	3.1 b
5	Neem	9.6 b	8.5 b	6.7 b	5.2 bc	3.8 bc	2.2 bc
6	Control	11.8 a	13.0 a	16.4 a	17.5 a	9.1 a	5.8 a
LSD Values		0.8805	1.0497	0.8954	2.2039	1.3247	0.9003

*Means followed by same letter within each column are not significantly different from each other at 5 % level of probability.

It is further evident that after 7th day of spray (7th of September) that larval population reduced with significant difference ($F_{5,\ 10}$ = 63.07, p<0.0000) till this observation. The lowest population was observed in Emamectin benzoate (2.4 larvae plant^{-1}) which gave significant difference from other treatment whereas it was followed by Lannate (3.3 larvae plant^{-1}), Lufenuron (4.5 larvae plant^{-1}), Neem (5.2 larvae plant^{-1}), Bakain (6.1 larvae plant^{-1}) and control (17.5 larvae plant^{-1}).

Third time treatments were applied on 8th of September. The results (Table-iii) after 3rd day of spray (11th of September) described that Emamectin benzoate was highly toxic against

Plutella xylostella larvae which gave significant result ($F_{5, 10}$ = 46.95, p<0.0000) with average number of (0.9 larvae plant^{-1}) followed by Lannate (1.8 larvae plant^{-1}), Lufenuron (3.2 larvae plant^{-1}), Neem (3.8 larvae plant^{-1}), Bakain (4.7 larvae plant^{-1}) and control (9.1 larvae plant^{-1}).

After 7th day of spray (16th of September) data evident that pest population significantly declined ($F_{5, 10}$ = 47.03, p<0.0000) and lowest population was found in Emamectin benzoate (0.5 larvae plant^{-1}) which is followed by (Lannate 0.7 larvae plant^{-1}), Lufenuron (1.8, larvae plant^{-1}), Neem (2.2 larvae plant^{-1}), Bakain (3.1 larvae plant^{-1}) and control (5.8 larvae plant^{-1}).

Overall Effect of Different Insecticides against P. xylostella Larvae

An overall view of the data (Figure-I) revealed that all the tested synthetic insecticide and botanical extracts induced variable level of effect on larval population density so it is proved that Emamectin benzoate was highly toxic with lowest mean number of population 3.0 larvae plant^{-1}which is followed by Lannate (4.1), Lufenuron (5.2), Neem (6.0), and Bakain (6.8) larvae plant^{-1}, respectively. It is concluded that both botanical extract were least toxic as compared to synthetic insecticides.

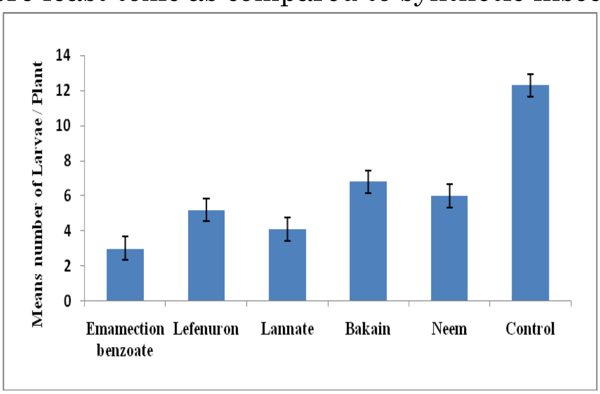

Figure-I: Overall effects of different Insecticides against P. xylostella larvae.

Yield Assessment

Data (Table-IV) indicated that there were significant differences ($F_{5,\ 10}$ = 76.23, p<0.0000) in yield between the insecticides treated plots and the control. A significant difference in yield was detected among the insecticidal treatments. Highest yield (30,533) Kg ha^{-1} was recorded in Emamectin treated plots with a percent yield increase of (82.5%) followed by Lannate treated plots (25,306) Kg ha^{-1} with a percent yield increase of (78.9%) whereas, the lowest yield (5,373) Kg ha^{-1} was recorded in the control plots.

Table-IV: The effect of synthetic insecticides and botanical extracts on yield (Kg ha^{-1}) recorded on cauliflower during the experimental period of July – September 2012.

S. No.	Treatments	Yield Kg ha^{-1}	Increased in yield over control (%)
1	Emamectin benzoate	30,533 a*	82.5
2	Lufenuron	16,953 c	68.5
3	Lannate	25,306 b	78.9
4	Bakain	9,333 d	42.8
5	Neem	12,733 d	58.1
6	Control	5,373 e	*****
LSD Values		5.2138	*****

*Means followed by same letter within each column are not significantly different from each other at 5 % level of probability.

Discussion

Diamondback moth (*Plutella xylostella)* is the most destructive pest in this region and has been recorded to cause up to 100%

yield losses in Pakistan. Therefore, an experiment was conducted to compare the efficacy of synthetic insecticides and botanical extracts against *P. xylostella* larvae under laboratory and field conditions (Abro. *et al* 1994).

Both the laboratory bioassay and field tests revealed that the pest mortality was significantly lower in control as compared with insecticides. Among all the tested insecticides, Emamectin benzoate gave maximum larval mortality and was significantly superior over others, followed by Lannate. The insect growth regulator (Lufenuron) exhibited minimum efficacy indicating slow mode of action. In the botanicals, Neem was superior to Bakain but not at par with any of the synthetic chemicals.

Our finding regarding the laboratory bioassays are in conformity with Bian-tao *et al.,* (2011) who reported that Emamectin benzoate caused results proved that Emamectin and Lufenuron caused 90 to 100% mortalities to larvae and adults of *P. xylostella*, We agree with scientist regarding Emamectin Benzoate which caused 90.8 % mortality after 72 hours while our results regarding Lufenuron toxicity to the pest are somewhat different than the fore mentioned workers as we recorded it to caused 60% mortality .

Our finding about Emamectin benzoate against *P. xylostella* larvae are in accordance with the results of scientist Muhammad (2005) and Shi *et al* (2004), who reported that Emamectin benzoate was most effective against larvae as compared to the Lufenuron. The chemical other closely related compounds were found to be afficious on lepidopteron larvae. (Dybas and Babu, 1988; Lasota and Dybas, 1991).

Efficacy of selected insecticides against *P. xylostella* revealed that Neem and Lufenuron were moderately effective, causing 50 % and 60 % respectively, mortality so our findings on the subject of Lufenuron and Neem are in agreement with Pandey and Raju (2003) who reported that the insect growth regulators and Neem products can give an effective control of *P. xylostella* larvae in laboratory bioassays.

Results regarding study under field conditions revealed that the insect growth regulator, Lufenuron exhibited low efficacy indicating slow mode of action which is in agreement with the findings of Goud *et al* (2009). However, for a related chemical, Novaluron and Flufenoxuron the observation made above scientist are contrary to our findings who reported that insect growth regulator were highly effective against *P. xylostella* larvae. One possible reason for variation in the results during the present investigation may be due to difference in the insecticide molecule or attributed to development of resistance by the pest to the particular insecticide.

The result of present study exhibited that the application of Neem and Bakain was least effective against *P. xylostella* larvae and reducing population up to 2.10 larvae plant^{-1}. Charleston *et al.*, (2006) reported that the effect of three different doses of botanical insecticides derived from the syringe tree, *M. azedarcha* and *A. indica* tree were determined on the behavior of the *P. xylostella.* Both the botanical insecticides had a great effect on larval stage which decreased population to up to 2-5 larvae plant^{-1}. Xu (2004) investigated that products of *A. indica* plant whether extracted from leaves, seed or other parts have been extensively used as botanical insecticides. He further reported that pesticide based on *A. indica* plant were possibly one of the most promising products among so many kinds of botanical pesticides.

Our finding regarding Neem seed extract are in conformity with Pandey and Raju (2003) who reported that *A. indica* based formulations do not usually kill insects directly, but they can alter their behavior in significant ways to reduce pest larvae in the crops, and reduce their reproductive potential.

We observed higher yield in the insecticides treated plots as compared to control plots which are in line with the findings of Rosli *et al*., (1979) who stated that the control plots gave significantly lower yield of marketable heads as compared to the insecticide treated plots. These results further confirmed the reports that insecticides were effective in protecting the cabbage from yield loss thus promoting higher yields (Chuo, 1973; Creighton and McFadden, 1975).

Conclusions

Laboratory and field tests revealed that Emamectin benzoate was significantly more toxic to the pest as compared to the rest of insecticides. The botanical extracts though moderately efficacious, were slow in exerting their lethal effects. It could be suggested that there is potential to use Emamectin benzoate in combination with the botanical insecticides to maintain the population of this pest below damage level.

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