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Stress Management

Evaluation of Certain Insecticides against Diamondback Moth (DBM) *Plutella xylostella* on Cauliflower

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Abstract

Studies were carried out in field condition during *rabi*, from November 2017 to February 2018 at Acharya N. G. Ranga Agricultural University, Agricultural College Farm, Naira, to evaluate the efficacy of certain newer insecticides against diamondback moth (DBM) *Plutella xylostella* on Cauliflower. The findings of the experiment revealed that all the chemicals evaluated against Diamond back moth larvae were significantly superior to check in protecting cauliflower from Diamond Back Moth at 3 and 7 days after treatment. Among all the tested insecticides, Spinosad 45 SC, Indoxacarb 14.5 SC and Emamectin benzoate 5% SG proved to be the most effective treatments in reducing the larval population of Diamond Back Moth. During the study Flubendiamide 39.35 SC and Thiodicarb 70 SP were found moderately effective against Diamond back moth. The treatments Lufenuron 5 EC and Acephate 75 WP were found least effective. The highest marketable yield of Cauliflower heads was recorded in Spinosad 45 SC (228.80 q ha^{-1}). It was followed by Indoxacarb 14.5 SC (219.10 q ha^{-1}) and emamectin benzoate 5% SG, which yielded (193.90 q ha^{-1}) Flubendiamide 39.35 SC, Thiodicarb 70 SP, Lufenuron 5 EC and Acephate 75 WP yielded the lowest marketable yields of 165.90, 145.50, 120.80 and 108.00 q ha^{-1} respectively. The highest Cost Benefit (C:B) ratio of 69.85 was obtained with the treatment Indoxacarb 14.5 SC followed by Emamectin benzoate 5% SG (60.18), Spinosad 45 SC (30.13) and Flubendiamide 39.35 SC (24.56).

Keywords: *Plutella xylostella*, cauliflower, insecticides, management

1. Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* Linn.) is an economically important winter vegetable of the several vegetables in the species *Brassica oleracea.* It contains many nutrients particularly substantial amounts of vitamins (Vit. C, K, B_6) and minerals (Mn, P, K). In India, it is cultivated in an area of 4.26 lakh ha. with an average annual production of 8199 mt and productivity of 19.2 mt ha^{-1} (www.indiastat.com, 2014–15). The yield of cauliflower is adversely affected by many bottlenecks including insect pest, diseases, environmental stresses, nutritional imbalance *etc*. Insect pests are of prime importance as they cause serious economic damage to cauliflower crop. Among all, diamondback moth (DBM), which was long considered a relatively insignificant pest, is now becoming a major pest. Cauliflower and cabbage are the most preferred host plants as their fleshy and succulent leaves provide necessary olfactory and gustatory stimuli for successful selection and colonization.

In India, Krishnamoorthy (2004) reported 52% yield loss on cabbage due to diamondback moth, whereas Lingappa et al. (2006) reported that the yield loss caused by this pest varied from 31-100%. The overall management cost in world for diamondback moth is estimated at US $ 4-5 billion annually (Zalucki et al., 2012). To control this pest, insecticides have been used indiscriminately, resulting, in the development of resistance to every synthetic insecticide used against it in the field (Talekar et al., 1990). In India, the first report of insecticide resistance development in diamondback moth was around 1966 in Ludhiana, Punjab, against DDT and Parathion (Verma and Sandhu, 1968). After that, the pest has developed resistance to about 82 compounds belonging to different classes of insecticides over 17 countries (Furlong et al*.,* 2013).

The crop production strategies have however experienced a paradigm shift from pest “control’’ to pest “management’’. But the management of this pest has become a stupendous task and farmers are compelled to use chemical insecticides in order to cultivate lucratively, as traditional and cultural practices alone cannot give satisfactory control over the pest. Vegetables retain residues of a cocktail of chemicals since these are applied at different stages of crop growth and even just before harvest, resulting in health hazards to the consumers. As exclusion of chemical insecticides is impracticable, it has necessitated the use of alternative eco-friendly insecticides for sustainable management of *P. xylostella* which can return diamondback moth to minor pest status by favoring survival of natural enemies and the development of resistance against these traditional insecticides can be easily broken down by using the new group of molecules. Keeping in view of the seriousness of the pest and economic importance of this crop, the present investigation was carried out to evaluate the efficacy of different insecticides viz*.,* Spinosad, Emamectin benzoate, Flubendiamide, Thiodicarb, Indoxacarb, Lufenuron and Acephate under field conditions at Agricultural College Farm, Naira, Andhra Pradesh for their comparative efficacy against *P. xylostella* on cauliflower, as a part of M. Sc. programme.

2. Materials and Methods

The experiment was laid out during 2017–18 in a randomized block design with eight treatments including untreated check replicated thrice with local cauliflower variety Karthika, raised and maintained with standard agronomic practices including normal weeding, irrigation practices, fertilization and sanitation *etc.* except plant protection measures, followed as per recommended package of practices of Acharya N. G. Ranga Agricultural University.

Individual plots were divided into ridges and furrows with plot size each of 20×10 m^2 forming bunds all around. Thirty days old seedlings of cauliflower were transplanted on 27^{th} Nov 2017 at row to row and plant to plant distance of 60×45 cm^2, respectively. When the pest reached its minimum ETL (Economic Threshold Level) the first spraying was done, and further sprayings were given at scheduled spray intervals.

Measured quantity of insecticide was mixed in small quantity of water and later made up with water to required volume of spray fluid. Each plot received 0.6 liters of spray fluid @ 500 l ha^{-1}. The spray fluid was thoroughly stirred before spraying. Spraying was done with a knapsack sprayer in the morning hours to the point of run off for thorough coverage. The sprayer used for spraying was cleaned thoroughly after application of each chemical.

Data on the pest population was recorded at one day before spraying as pretreatment count and 3^{rd} and 7^{th} day after spraying as post treatment counts. The observations were recorded from ten randomly selected plants $plot^{-1}$ leaving the border rows. The data on total number of larvae per head and % head damage were recorded.

2.1. Statistical analysis

The % population reduction in different treatments over untreated check was calculated by the modified Abbot's formula (Fleming and Ratnakaran, 1985) and the data were subjected to ANOVA. The % reduction values were duly transformed into corresponding angular values and the data were subjected to statistical analysis (Gomez and Gomez, 1984).

Healthy cauliflower heads were harvested when they reached appropriate marketable size and their weight from each treatment was expressed as marketable yield in q ha^{-1} and subjected to statistical analysis to test the significance of mean yield in different treatments. The % increase in yield of cauliflower heads over control in each treatment was calculated by using the formula,

% increase of yield over control =(Yield in treatment-Yield in untreated control)/yield in untreated control×100

Later the yield data were subjected to statistical analysis. To determine the most effective and economic treatment, Cost Benefit ratio (CBR) of different treatments worked out by taking into consideration the cost of insecticides used, labor cost and prevailing market price of cauliflower.

3. Results and Discussion

The population of diamondback moth recorded before spraying was found to be non-significant among the different treatments, which indicated that the infestation of diamondback moth was homogenous.

3.1. Overall pooled efficacy of first spray

The mean data after first spray (Table 1) recorded at 3 and 7 DAT showed that Spinosad 45 SC was found to be the best and most effective treatment with a reduction of 86.35% over untreated control and significantly superior over all other treatments. The treatment indoxacarb 14.5 SC (78.15%) was also found to be good with more than 78% reduction in population of *P. xylostella* over control and was also significantly superior to remaining treatments. The next best treatment was emamectin benzoate 5% SG with 68.20% reduction of larval population of superior over other remaining treatments. Flubendiamide 39.35 SC, thiodicarb 70 SP, lufenuron 5 EC and acephate 75 WP were found to be significantly the least effective treatments being on par with a reduction of 59.40, 52.70, 45.15, and 36.45% over untreated control.

3.2. Overall pooled efficacy of second spray

The overall efficacy of the post treatment observations recorded at 3 and 7 DAT after second spray (Table 1) showed that spinosad 45 SC, indoxacarb 14.5 SC and emamectin benzoate 5% SG were found to be the best and the most effective being on par with 83.35, 76.65 and 70.15% reduction in population over untreated control and were significantly superior to all other treatments. The treatments flubendiamide 39.35 SC (56.95%) and thiodicarb 70 SP (49.40%) were also found to be good with more than 49% reduction in population of *P. xylostella* over control and was also significantly superior to remaining treatments.

Among the treatments lufenuron 5 EC and acephate 75 WP were found to be on par with 47.30 and 38.50% reduction in population over untreated control and were significantly the least effective treatments of diamondback moth

Table 1: Efficacy of insecticides against *P. xylostella* on cauliflower during *rabi*, 2017–18

Treatments	(First spray)				(Second spray)			
	Pretreatment count	Mean per cent population reduction over untreated check		Overall mean efficacy	Pretreatment count	Mean per cent population reduction over untreated check		Overall mean efficacy
		3 DAT	7 DAT			3 DAT	7 DAT	
Spinosad 45 SC @ 0.3 ml l^{-1}	50.70 (45.36)*	87.80 (69.65)[a]	84.90 (67.32)[a]	86.35 (68.44)[a]	44.0 (41.52)*	84.60 (67.12)[a]	82.10 (64.96)[a]	83.35 (66.03)[a]
Emamectin benzoate 5% SG @ 0.4 g l^{-1}	47.70 (43.64)	69.90 (56.74)[c]	66.50 (54.60)[c]	68.20 (55.86)[c]	39.0 (38.61)	72.50 (58.39)[b]	67.80 (55.46)[a]	70.15 (57.10)[a]
Flubendiamide 39.35 SC @ 0.2 ml l^{-1}	49.70 (44.79)	61.80 (51.84)[d]	57.00 (49.01)[d]	59.40 (50.48)[d]	40.0 (39.21)	61.40 (51.57)[c]	52.50 (46.40)[b]	56.95 (48.73)[b]
Thiodicarb 70 SP @ 1 g l^{-1}	51.70 (45.93)	55.10 (47.90)[e]	50.30 (45.17)[e]	52.70 (46.43)[d]	42.7 (40.76)	53.70 (47.07)[d]	45.10 (42.14)[c]	49.40 (44.71)[c]
Indoxacarb 14.5 SC @ 1 ml l^{-1}	54.30 (47.47)	79.30 (63.00)[b]	77.00 (61.36)[b]	78.15 (62.37)[b]	44.0 (41.51)	77.70 (61.89)[a]	75.60 (60.49)[a]	76.65 (61.00)[a]
Lufenuron 5 EC @ 0.8 ml l^{-1}	50.70 (45.36)	49.20 (44.51)[f]	41.10 (39.84)[f]	45.15 (42.42)[d]	37.0 (37.44)	47.30 (43.42)[e]	37.70 (37.86)[d]	42.50 (40.69)[d]
Acephate 75 WP @ 1.5 g l^{-1}	48.70 (44.21)	41.20 (39.90)[g]	31.70 (34.23)[g]	36.45 (37.17)[d]	40.0 (39.21)	38.50 (38.33)[e]	29.30 (32.75)[e]	33.90 (35.37)[d]
Untreated check (control)	51.70 (45.93)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	39.7 (39.01)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)
F test	NS	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.
SEm±		1.46	1.48	1.47		1.68	1.50	1.59
CD (p=0.05)		4.49	4.54	4.51		5.17	4.60	4.88

*Values in parentheses are angular transformed values; Sig.: Significant; NS: Non-Significant; DAT: Days after treatment; Values with same alphabet in each column do not vary significantly from each other

population by recording less than 39 % reduction. However, all the treatments were effective and significantly superior in reducing the larval population of *P. xylostella* over untreated control.

3.3. Overall Mean efficacy of both sprays

The overall efficacy of the post treatment observations recorded at 3 and 7 DAT of two sprays (Figure 1) showed that spinosad 45 SC, indoxacarb 14.5 SC and emamectin benzoate 5% SG were found to be the best and the most effective being on par with 84.85, 77.40 and 69.17% reduction in population over untreated control and were significantly superior to all other treatments. A voluminous research data to confirm the results of spinosad is available (Dey and Somchoudhury, 2001, Mahalakshmi et al., 2002, Prithwiraj and Chatterjee, 2003, Tambe and Mote, 2003, Syed et al., 2004, Walunj and Pawar, 2004, Wemin and Wesis, 2006, Jasmine et al., 2007, Kumar et al., 2007c, Sable et al., 2007, Meena and Singh, 2013, Vaseem et al., 2014, Stanikzi and Thakur, 2016, Reddy et al., 2017, Sharma et al., 2017a, Venugopal et al., 2017 and Yadav et al., 2017).

The results of indoxacarb are in conformity with the results of

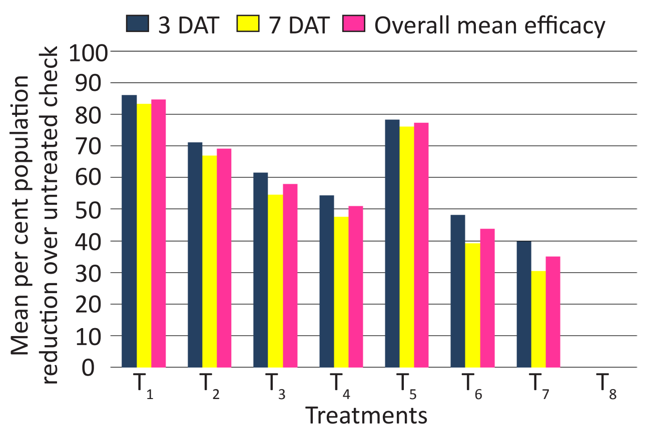

Figure 1: Cumulative efficacy of the treatments against *P. xylostella* on cauliflower during *rabi*, 2017–18

Liu et al. (2003), Martinelli et al. (2003), Sannaveerappanavar et al. (2003), Kumar et al. (2007a), Sable et al., 2007), Chakraborty and Somchoudhury (2011), Ismail et al. (2012), Meena and Singh (2013), Karthik et al. (2015), Patra et al. (2016), Stanikzi and Thakur (2016), Patra et al. (2017), Selvaraj and Kennedy (2017), Sharma et al. (2017a) and Yadav et al.

(2017) against diamondback moth. The results of emamectin benzoate are in conformity with the results of Suganyakanna (2003), Suganyakanna et al. (2005), Kumar and Devappa (2006), Matthew (2007), Shivalingaswamy et al. (2008), Kailash et al. (2016), Stanikzi and Thakur (2016), Reddy et al. (2017) and Sharma et al. (2017a).

The next effective treatments that have shown a moderate degree of efficacy were flubendiamide 39.35 SC (58.17%) and thiodicarb 70 SP (51.05%) with more than 52% reduction in population of *P. xylostella* over control and were also significantly superior to remaining treatments. Similar results regarding the efficacy of flubendiamide obtained in the present investigation also corroborating with the earlier findings of several researchers (Kumar et al*.,* 2007b, Selvaraj and Kennedy, 2017 and Sharma et al., 2017a) conforming the outcome of the present study. The treatment of thiodicarb existed in moderately effective group of insecticides in the present investigation which corroborate with the findings of Katra and Sharma (2000), Vastrad et al. (2002) and Sable et al. (2007). However, the present results do not corroborate with that of Mandal and Mandal (2009) who reported thiodicarb 75 SP as less effective insecticide against *P. xylostella* on cauliflower. The difference in efficacy of insecticides may probably be due to the pressure of pest population and doses used for controlling the pest.

Among the treatments lufenuron 5 EC and acephate 75 WP were significantly the least effective treatments being on par with 43.82 and 35.17% reduction in diamondback moth population over untreated control. These results regarding the efficacy of lufenuron are in concordant with Senguttuvan and Kuttalam (2013) and Sharma et al. (2017b) against DBM population but do not corroborate with the findings of Vastrad et al. (2002) and Kulye et al. (2007) who reported lufenuron as the most effective insecticide against *P. xylostella* population. The performance of acephate is in accordance with Ojha et al. (2004a), Mandal and Mandal (2009) and Sharma et al. (2017a). The present results however, gets partial support from the results of Selvaraj and Kennedy (2017), who found acephate as a moderately effective insecticide against DBM population. However, all the treatments were effective and significantly superior in reducing the larval population of *P. xylostella* over untreated control.

Among the treatments lufenuron 5 EC and acephate 75 WP were significantly the least effective treatments being on par with 43.82 and 35.17% reduction in diamondback moth population over untreated control. These results regarding the efficacy of lufenuron are in concordant with Senguttuvan and Kuttalam (2013) and Sharma et al. (2017b) against DBM population but do not corroborate with the findings of Vastrad et al. (2002) and Kulye et al. (2007) who reported lufenuron as the most effective insecticide against *P. xylostella* population. The performance of acephate is in accordance with Ojha et al. (2004a), Mandal and Mandal (2009) and Sharma et al. (2017a). The present results however, gets partial support from the results of Selvaraj and Kennedy (2017), who found acephate as a moderately effective insecticide against DBM population. However, all the treatments were effective and significantly superior in reducing the larval population of *P. xylostella* over untreated control.

3.4. % head damage at the time of curd harvest

% head damage on cauliflower plants at the time of curd harvest indicated that the lowest % of head damage of 8.48 was recorded in the treatment spinosad 45 SC followed by indoxacarb 14.5 SC (12.36), emamectin benzoate 5% SG (22.44), flubendiamide 39.35 SC (33.64), thiodicarb 70 SP (41.80), lufenuron 5 EC (51.68) and acephate 75 WP (56.80). However, all the treatments were significantly superior to untreated check which recorded the highest % head damage of 64.32 in terms of % head damage.

3.5. Effect of insecticidal treatments on curd yield during Rabi 2017-18

Since all the agronomic practices except the plant protection treatments remained the same, the variation in yield was attributed to the effect of the treatments in reducing yield losses by insect pests. During harvest, healthy heads without any pest infestation were separated and weighed separately, which was treated as marketable yield.

The data on yield recorded in different insecticidal treatments is presented in Table 2 revealed that spinosad 45 SC, as a result of its higher efficacy in reducing the pest incidence in terms of % larval population, it recorded highest yield of 228.80 q ha^{-1} with 156.50% higher yield over untreated control and these results are in conformity with the earlier results of Tambe and Mote (2003), Sable et al. (2007), Meena and Singh (2013), Vaseem et al. (2014) and Sawant and Patil (2017) who recorded 222 q ha^{-1}, 214.42 q ha^{-1}, 233.5 q ha^{-1}, 224.74 q ha^{-1} and 236.91 q ha^{-1} of marketable cauliflower heads, respectively with spinosad. It was followed by indoxacarb 14.5 SC (219.10 q ha^{-1}) with 145.62% higher yield over untreated control which is in accordance with reports of Sable et al., 2007 (206.94 q ha^{-1}) and Meena and Singh, 2013 (226.8 q ha^{-1}) who reported higher yields of cauliflower with indoxacarb. Emamectin benzoate 5% SG also recorded good yields 193.90 q ha^{-1} with 117.37% increase in yield over control. Regarding the efficacy of emamectin benzoate in recording good yields is in conformity with Kumar and Devappa (2006) who reported higher yield of cabbage heads 113.23 and 95.80 kg $plot^{-1}$ with emamectin benzoate @ 150 g a.i. ha^{-1} and 200 g a.i. ha^{-1}, respectively.

The descending order of efficacy among the rest of the treatments to visualize through curd yield was flubendiamide 39.35 SC (165.90 q ha^{-1}), thiodicarb 70 SP (145.50 q ha^{-1}), lufenuron 5.40 EC (120.80 q ha^{-1}) and acephate 75 WP (108.00 q ha^{-1}) recorded 85.98, 63.11, 35.42 and 21.07% increase in yield over control, respectively. Regarding the curd yield in treatment flubendiamide, the present results obtain partial conformity with Sawant and Patil (2017) who recorded

Table 2: Effect of the treatments on the curd yield of cauliflower during rabi, 2017-18

Treatments	Mean curd yield (kg plot^{-1})	Curd yield (q ha^{-1})	% increase over control
Spinosad 45 SC @ 0.3 ml l^{-1}	45.8	228.80	156.50
Emamectin benzoate 5% SG @ 0.4 g l^{-1}	38.8	193.90	117.37
Flubendiamide 39.35 SC @ 0.2 ml l^{-1}	33.2	165.90	85.98
Thiodicarb 70 SP @ 1 g l^{-1}	29.1	145.50	63.11
Indoxacarb 14.5 SC @ 1 ml l^{-1}	43.8	219.10	145.62
Lufenuron 5 EC @ 0.8 ml l^{-1}	24.2	120.80	35.42
Acephate 75 WP @ 1.5 g l^{-1}	21.6	108.00	21.07
Untreated check (control)	17.8	89.20	0.00
F test	Sig.	Sig.	
SEm±	1.4	6.8	
CD (p=0.05)	4.1	20.7	

Sale price of cauliflower – ₹ 900/q

228.49 q ha^{-1} marketable cabbage heads with flubendiamide 18.24 g a.i ha^{-1}. The significant increase in the curd yield in the treatment thiodicarb (145.50 q ha^{-1}) over control was obtained in present findings and gets partially support from the work of Sable et al. (2007) who recorded 128.46 q ha^{-1}. The present results do not corroborate with the results of Vastrad et al. (2002) and Mandal and Mandal (2009) who recorded the curd yield as 340 q ha^{-1} and 189.52 q ha^{-1}, respectively. Regarding the curd yield in treatment flubendiamide, the present results obtain partial conformity with the work of Senguttuvan and Kuttalam (2013). The treatment acephate recorded lowest curd yield in the present investigation and the results partly get support from the work of Ojha et al. (2004a) and Mandal and Mandal (2009) who reported that acephate was least effective against *P. xylostella* population with lower curd yields.

3.6. Cost benefit ratio (CBR) of different treatments during rabi 2017-18

The Cost Benefit ratios (CBR) among various insecticidal treatments varied between 1: 69.85 to 1:12.95. Maximum (1: 69.85) CBR was recorded with indoxacarb 14.5 SC followed by emamectin benzoate 5% SG (60.18), spinosad 45 SC (30.13), flubendiamide 39.35 SC (24.56), thiodicarb 70 SP (21.03), lufenuron 5.40 EC (13.24) and acephate 75 WP (12.95). The cost effectiveness of indoxacarb 14.5 SC might be due to the lower dosage of the chemical against DBM larval population coupled with low market price of the treatment.

4. Conclusion

Spinosad 45 SC, indoxacarb 14.5 SC and emamectin benzoate 5% SG proved to be the most effective treatments in reducing DBM larval population. The highest yield was recorded in spinosad 45 SC (228.80 q ha^{-1}) followed by indoxacarb 14.5 SC (219.10 q ha^{-1}). The C:B ratio of 69.85 was obtained from indoxacarb 14.5 SC followed by emamectin benzoate 5% SG (60.18) and spinosad 45 SC (30.13).

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