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"Investigation On IPM Interventions In The Management Of Diamondback Moth (*Plutellaxylostella)* On Cauliflower(*Brassica oleraceae var. botrytis*)"

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I. INTRODUCTION

The cauliflower (*Brassica oleracea*L. var. *botrytis*) is one of the most important cole crops grown widely throughout the country. It is mostly grown during winter season in the plains for its white tender curds formed by the shortened flower parts. Its edible curd is made-up of abortive flowers, the stalk of which are fleshy and loosely crowded. It is herbaceous annual for vegetable production and biennial for seed production.

India is the second largest producer of vegetables in the world, next to China. These are grown in 8.5 million hectares with a production of 146.55 million tonnes forming 14.90 and 14.48 per cent, respectively to the world area and production.India is the largest producer of cauliflower in the world. The major cauliflower growing states are Bihar, U.P. Orrisa, Best Bengal and Maharastra. Out of total area under vegetables, cauliflower alone occupies 5.01% area *i.e.*0.426 million hectares with an annual production of 8.615 million metric tonnes during the 2017-18. (Indian Horticulture Database,2019)

Insect pests viz.,Diamondback moth, *Plutellaxylostella*(L.), common cutworm, *Spodopteralitura*(F.), cabbage butterfly, *Pierisbrassicae*(L.), cabbage aphid, *Brevicorynebrassicae*L., cabbage looper, *Trichoplusiani*H., and head borer, *Hellulaundalis*(F.)constitute a major problem in cauliflower production (Sable *et al.,* 2008). With thedevelopment of new hybrids and varieties, cauliflower is now being grownthroughout the year. As a result, the risk of damage from the pests has greatlyincreased and farmers depend mostly on application of various insecticides to protectthe crop. Due to poor knowledge, farmers resort to indiscriminate sprays for reducingpest density. This practice not only contaminates the harvested produce with harmfulpesticides residues causing health hazards but also destroys the beneficial fauna andpollutes the environment. Many field populations of *S. litura*, *P. xylostella*and otherinsect pests of cole crops have developed multiple resistances to commonly usedinsecticides and field control failure has been observed very frequently (Ribeiro*et al.,* 2014).

II. MATERIAL AND METHODS

The present research work entitled **"Investigation on IPM Interventions in the Management of Diamondback Moth (*Plutellaxylostella)* on Cauliflower (*Brassica oleraceae var. botrytis*)"** was conducted at Agricultural Farm of Raja Balwant Singh College, Bichpuri, Agra, during Rabi season of 2020-21. The experimental material used, experimental techniques and methodology adopted during the course of investigation have been described in this chapter.

2.1 Location of study area

Agricultural Farm, R.B.S. College, Bichpuri, Agra is situated at an elevation (altitude) of 169.4 m above mean sea level, 27.2^{0}N latitude and 77.9^{0}E longitude. Bichpuri is located at about 11 km. west of Agra city on Agra-Bharatpur Road, in semi-arid eco-system/region IV (AESR 4.1) and Agro-climatic Zone 'NWPZ' (North Western Plains Zone).

2.2 Evaluation of Integrated Pest Management module against Diamondback moth *(Plutellaxylostella)*on cauliflower

2.2.1 Details of the treatments (modules)

M_1	:	Integrated pest management (IPM) module
M_2	:	Sole application of chemical insecticides
M_3	:	Sole application of botanical insecticides
M_4	:	Untreated control

Design	**:**	RBD
Replications	**:**	Three
No. of treatments	**:**	Four
Total no. of plots	**:**	12
Gross plot size	**:**	5×12 m =60 m^2
Net Plot Size	**:**	4.5×11.5m =51.75 m^2
Spacing	**:**	50×50 cm

2.2.2 Cultural operations

The experimental field was ploughed with a tractor drawn disc plough followed by cross harrowing and planking. Keeping in consideration that- *i)* no clods should be in the field to interfere with root development, and *ii)* the soil should not contain any un-decomposed organic matter. The planking was done to bring the field to a fine tilth.

2.2.3 Application of fertilizers

N, P and K fertilizers were applied as per treatments keeping the recommended doses 160 kg N, 80 kg P_2O_5 and 60 kg K_2O respectively through urea, single super phosphate and muriate of potash. The half amount of urea and total quantity of single super phosphate and muriate of potash were applied as basal dressing and the remaining half quantity of urea was applied as top dressing after one month of planting.

2.2.4 Transplanting and gap filling

Transplanting was done on 4thDecember, 2020 and gap filling was attended 4 days after transplanting.

2.2.5 Interculture

Timely weeding and interculture operations were carried out as and when required.

2.2.6 Irrigation

Timely irrigations were given as and when required at different stage of the crop.

2.3 Time and methods of applications of treatment

2.3.1 IPM module (M_1)

Consisted of following components

a) Use of pheromone trap

A pheromone trap (lure of *P. xylostella)* was installed at 10 days after transplanting in the middle of plot and lure was recorded at 15 days intervals regularly.

b) Use of bio-pesticides

The application of neem-based insecticides and microbial insecticide (B. t) was made in the following manner.

The 1stapplication of NSKE 3 per cent was made at the appearance of the diamondback moth damage. The subsequent application of B.t. var. Kurstaki was given at 10 days after the 1stapplication, which synchronized with third instar larvae of diamondback moth. Thereafter two sprays each of Econim 0.5 per cent and NSKE 3 per cent were given at 10 days interval.

III. RESULTS AND DISCUSSION

The IPM module (M_1) was comparedwith another two modules; comprising use of sole chemicalinsecticides (M_2) and use of sole botanical insecticides (M_3)against Diamondback moth. The results obtained are presented in this chapter fully supported by graphs and tables, wherever necessary. The obtained results have been analyzed statistically and the analyses of variance for different studies are presented in Appendices. The results have been presented experiment wise, along with discussion.

3.1 Evaluation of Integrated Pest Management module against Diamondback moth *(Plutellaxylostella.)*

3.1.1 Effect on larval population of Diamondback moth

The data on larval population of Diamondback moth arepresented in Table-4.1. The pre-spraying observation recorded atfive weeks after transplanting (WAT) showed non-significantdifferences among the treatments.

At the 6thweek after transplanting the results-indicatedthat all the three modules recorded significantly lowerDiamondback moth larval population as compared to control (4.6larvae /10 plants). Among the different treatments, significantlyminimum larval population was recorded in the treatment of solechemical insecticides (M_2) (1.4/10 plants) and it was at par withtreatment of sole botanical insecticides (M_3) (1.8/10plants) andtreatment of IPM module (M_1) (2.0/10 plants).

At the 7thWAT, the perusal of data indicated that thelowest Diamondback moth larval population was recorded intreatment M_1 (0.6/10 plants) and it was statistically at par withother modules, except untreated control (M_4) (5.4/10 plants).

The observations recorded at 8thWAT showed that allthe treatment modules were significantly superior over untreatedcontrol (6.8/10 plants) and they were at par with each other.However, minimum larval population recorded in treatment M_3(0.4/10plants) followed by treatment M_2 (0.6/10plants) and M_1(0.6/10plants).

The data obtained on number of Diamondback mothlarvae as affected by different treatments at 9thWAT, indicatedthat significantly lower number of larvae was found in treatmentM_1 (2.2/10plants) and it was at par with treatment M_3(2.6/10plants) and treatment M_2 (3.0/10plants).
At the 10thWAT, the lower larval population wasrecorded in M_1 module (1.4/10plants) which was at par with M_3(1.8/10plants), while M_2 was inferior (2.4/10plants) to M_1andsuperior over untreated control (l.2/10plants).
At the 11thWAT, the data revealed that all the threetreatments recorded significantly a smaller number of larvae ascompared to untreated control (10.20/10plants). Further, all thethree treatments remained at par with each other. However,comparatively lower population was recorded in M_1(2.2/10plants) followed by M_3(2.40/10plants) and M_2(2.80/10plants).

Table 4.1 Mean population of Diamondback moth larvae in different treatment Modules

Treatments (Module)	Mean population of DBM larvae per 10 plants							
	Date of Observation							
	Pre-spraying 02-01-2021	09-01-2021	16-01-2021	23-01-2021	30-01-2021	07-02-2021	14-02-2021	Pooled mean
	5 WAT	6 WAT	7 WAT	8 WAT	9 WAT	10 WAT	11 WAT	
M_1	4.20 (2.15)	2.00 (1.55)	0.60 (1.02)	0.60 (1.02)	2.20 (1.64)	1.40 (1.33)	2.20 (1.64)	1.50 (1.41)
M_2	4.20 (2.16)	1.40 (1.32)	1.00 (1.19)	0.60 (1.02)	3.00 (1.84)	2.40 (1.70)	2.80 (1.80)	1.87 (1.54)
M_3	4.00 (2.11)	1.80 (1.50)	1.20 (1.26)	0.40 (0.91)	2.60 (1.75)	1.80 (1.51)	2.40 (1.70)	1.70 (1.48)
M_4	3.80 (2.06)	4.60 (2.25)	5.40 (2.42)	6.80 (2.70)	10.80 (3.36)	12.00 (3.52)	10.20 (3.25)	8.30 (2.97)
SEm±	0.11	0.13	0.13	0.12	0.09	0.11	0.12	0.09
CD at 5%	NS	0.40	0.40	0.37	0.29	0.35	0.37	0.28

Values in parentheses are $\sqrt{b+0.5}$ transformed values, WAT-weeks after Transplanting
1st Spray=02-01-2021, 2nd spray=09-01-2021,3rd spray=16-01-2021, 4th spray=23-01-2021, 5th spray=30-01-2021, 6th spray=07-02-2021, 7th spray=14-02-2021
The pooled analysis of data on number of Diamondbackmoth larvae as affected by various treatments revealed that all thethree modules proved their effectiveness in regulating larvalpopulation by recording significantly lower larval population ascompared to untreated control (8.3/10plants). However, the lowerlarval population was recorded in module M_1(1.51/10plants) whichwas at par with module M_3 (1.7/10plants) and module M_2(1.87/10plants)
It is evident from the above results that the all the threemodules were effective in reducing the Diamondback moth larvalpopulation as compared to control. However, IPM moduleexhibited more effectiveness compared to rest of the modules,which is evident from the lower number of larval populationsobserved throughout the observation period.

3.1.1.1 Number of *P. xylostella*moth caught in pheromone trap

IPM modulecomprising of physical control *i.e.* use of pheromone trap, playedimportant role in reducing male Diamondback moth population.The number of moths caught in pheromone trap was 18, 19, 23, 21and 20 in 1st, 2nd, 3rd, 4th, 5thand 6thstandard week, respectively(Table-2). Removal of large number of male population from IPM module in treatment area reduced the chances of mating. This has resultedinto reduction in subsequent occurrence of Diamondback mothlarval population. The present result is more or less similar withfindings of Reddy and Guerrero (2000), the reported that matingdisruption can be used to protect cabbage from *P. xylostella*with
pheromone trap and application of some supplementaryapplication of insecticides.

Table-4.2 Number of *P. xylostella*moth caught in pheromone trapduring the year 2020-2021

Month	Standard meteorological week	No. of moth caught
December 2021	48	0
	49	0
	50	0
	51	0
	52	0
January 2021	1	18
	2	19

	3	23
	4	21
February 2021	5	20
	6	20
	7	0
	8	0

The other component of IPM module, application of microbial insecticide *Bacillus thuringiensis*also helped in reducing the larval population of Diamondback moth Thakur and Sharma (2014) reported that Neem oil @ 0.3 per cent resulted in 100 per cent mortality of aphids (30.0 number/plant), *Baccillusthuriengiensis*(16000 IU/mg) gave complete mortality of *Pierisbrassicae*(5.0 larvae/plant) and neem oil caused 60 per cent reduction in DBM (2 pupae emerged out of 5 pupae) compared to 20 per cent reduction in Melia extract.PrasannaKumar*et al.* (2013) reported that different neem products, *viz.*, pulverized neem seed powder extract (PNSPE), pulverized neem seed powder formulation (PNSPF), neem soap and neem cake petrol-water extract (NCPE) and synthetic insecticides were found superior to control plots and recorded least number of insect pests with better yield of cauliflower. Further it was found that, although highest yield was recorded in PNSPE (76.17 t/ha), PNSPF (73.15 t/ha) and other insecticide treatments, like spinosad (76.37 t/ha), flubendiamide (61.97 t/ha) but, there was no significant difference among them.

Packiam and Ignacimuthu (2012) reported that PONNEEM, an oil formulation containing neem and pongamia (karanja) oils along with individual neem and karanja oils and nimbicidine, a commercial neem-based pesticide against fourth instar larvae of *Spodopteralitura*(Fab.).Okoth, *et al* (2002) reported that neem kernel cake powder water extract (NKCP-WE) and Dipel 2x (*Bacillus thuringiensis* var. kurstaki) in controlling the Diamondback moth (DBM), *Plutellaxylostella* Linn. (Lepidoptera: Yponomeutidae), while effectiveness spraying of neem and pongemia soaps and pulverized neem seed powder extract for the control of Diamondback moth larval population in cauliflower. was reported by Gajanana*et al.* (2004)

The sole application of botanical insecticides N.S.K.E. 3 per cent and Econim 10,000 ppm also proved effective in checking population of Diamondback moth larvae. Thus, remained comparable with that of IPM module.Similarly,BansodeandPurohit (2009) reported that the module (M_1) that comprised pheromone trap, application of *B. thuringiensis* and neem-based insecticides, recorded significantly lower DBM population.

The module comprising of sole chemical insecticides (M_2) was also effective in reducing larval population of Diamondback moth. Whereas, pooled data showed that it was equally effective to that of IPM and botanical insecticides module. Thus, the application of quinalphos 0.05 per cent, profenophos 0.07 per cent, malathion 0.05 per cent and endosulfan 0.07 per cent reduced the larval population of Diamondback moth.

The present findings are fully in accordance with Katroju*et al*. (2014) reported that profenophos (1000 g a.i. ha^{-1}) was found to be the most effective against Diamondback moth with maximum reduction in larval population (65.20 %), minimum per cent fruit damage (28.80 %) and maximum yield (11.21 tonne ha^{-1}) , similarly Reddy *et al.* (2017) found that profenophos (1000 g a.i.ha-1) to be the most effective one with a maximum reduction in *P.xylostella*population (70.20%).

3.1.2 Per cent leaf infested by Diamondback moth

Per cent leaf infested by Diamondback moth wasrecorded at weekly interval from the appearance of the pest and ispresented in Table-3. The data on pre-spraying leaf infestationwas recorded at 5thWAT revealed non-significant differencesamong the treatments.

At the 6thWAT, the perusal of data indicated that thelower leaf infestation by Diamondback moth larvae was recordedin treatment M_1 (6.39%) and it was statistically at par withtreatment M_3 (6.41%) and M_2 (6.98%). However, significantlyhigher leaf infestation was recorded in untreated control (9.14%).

At 7thWAT, the data revealed that lower leafinfestation was recorded in treatment M_1 (6.90%) which did notdiffer significantly from treatment M_3 (7.08%) and treatment M_2(7.35%). The higher leaf infestation was recorded in untreatedcontrol (10.71%).

The data recorded at 8thWAT showed that all thetreatments were significantly superior over untreated control(13.52%). Lower leaf infestation was recorded in treatment M_3(7.00%) and it was at par with treatment M_1 (7.07%) and M_2(7.20%).

At the 9thWAT, the perusal of data indicated that thelower leaf infestation by Diamondback moth was recorded intreatment M_3 (8.05%) which did not differ significantly from thetreatment M_1 (8.27%) and treatment M_2(9.06%).

At the 10thWAT, the lower leaf infestation wasrecorded in treatment M_3 (8.08%) and it was at par with treatmentM_1 (8.22%)and M_2 (9.71%). However, significantly higher leafinfestation was recorded in untreated control (13.92%).

Table-4.3Mean percentage of leafinfested by Diamondback moth larvae

Treatments (Module)	Mean percentage of leaf infested							
	Date of Observation							
	Pre-spraying 02-01-2021	09-01-2021	16-01-2021	23-01-2021	30-01-2021	07-02-2021	14-02-2021	Pooled mean
	5 WAT	6 WAT	7 WAT	8 WAT	9 WAT	10 WAT	11 WAT	
M_1	6.7 (2.68)	6.39 (2.62)	6.90 (2.72)	7.07 (2.75)	8.27 (2.96)	8.22 (2.95)	9.10 (3.10)	7.52 (2.83)
M_2	6.58 (2.66)	6.98 (2.73)	7.35 (2.80)	7.20 (2.77)	9.06 (3.09)	9.71 (3.20)	10.02 (3.24)	8.13 (2.94)
M_3	6.45 (2.64)	6.41 (2.63)	7.08 (2.75)	7.00 (2.74)	8.05 (2.92)	8.08 (2.93)	8.84 (3.06)	7.42 (2.81)
M_4	6.38 (2.62)	9.14 (3.10)	10.71 (3.35)	13.52 (3.74)	14.32 (3.85)	13.92 (3.80)	15.77 (4.03)	11.97 (3.53)
SEm±	0.43	0.63	0.68	0.70	0.80	0.84	0.80	0.30
CD at 5%	NS	1.93	2.09	2.16	2.48	2.58	2.47	0.84

Valuesin parentheses are $\sqrt{x+0.5}$ transformed values, WAT-weeks after Transplanting
1st Spray=02-01-2021, 2nd spray=09-01-2021,3rd spray=16-01-2021, 4th spray=23-01-2021, 5th spray=30-01-2021, 6th spray=07-02-2021, 7th spray=14-02-2021

over control. The net gain over control in different treatment wasworkout by deducting the cost of treatment from the grossrealization over control of each treatment. The prevailing market rates remained during field experimentation at R.B.S. College, Agricultural research farm, Bichpuri, Agra, were taken in to account for this purpose. Data obtained were summarized in Table- 4.7.
A perusal of data presented in Table-4.7 revealed that there was considerable impact of various treatment modules on economics of the factors under study in relation to the other effects on yield and expenditure involved in use of insecticide to control Diamondback moth in cauliflower.

Table-4.7 Yield and economics of the different treatment modules

Modules	**Yield ($kgha^{-1}$)**	**Increased yield over control ($kgha^{-1}$)**	**Gross realization over control(Rs. ha^{-1})**	**Cost of treatments**	**Net gain over control(Rs. ha^{-1})**	**I.C.B.R.**
M_1	18886.86	4064.58	60969	7508	53461	7.12
M_2	17705.68	2883.4	43251	3672	39579	10.78
M_3	18459.27	3636.99	54555	7115	47440	6.67
M_4	14822.28					
SEm±	643.9					
CD at 5%						

Total cost of insecticides including two labour per hectare for each spray @ 200 Rs/day/labour.
Market price of cauliflower Rs. 15.0 kg^{-1}
It can be clearly seen from the table that the highest gross realization over control was obtained in IPM module(Rs. 60969 ha^{-1}) followed by botanical insecticides module (M_3) and chemical insecticides module (M_2) i.e. Rs. 54555 $ha^{-1}$and Rs. 43251 ha^{-1}, respectively. Similar trend was observed while considering the net gainobtained over control in different treatments. Whereas, the highernet gain was obtained from IPM module M_1(Rs. 53461 ha^{-1}) followedby botanical insecticides module M3 (Rs. 47440 ha^{-1}) and solechemical insecticides module M_2 (Rs. 39579 ha^{-1}). In spite the highercost of treatment (Rs. 3003.00) in IPM module, it remained at topin giving higher net gain over control.

IV. SUMMARY AND CONCLUSION

The present investigation entitled **"Investigation on IPM Interventions in the Management of Diamondback Moth (*Plutellaxylostella)* on Cauliflower (*Brassica oleraceae*var. *botrytis*)"** was undertaken to find outsuitable ecofriendly management strategy for Diamondback moth,during*Rabi* season of 2020-21 at the Agricultural Research Farm of R.B.S. College, Bichpuri, Agra.
The variables involved in this study were different modules to control Diamondback Moth *viz*. M_1 (use of pheromone trap and 1st application of NSKE 3% at the appearance of the Diamondback moth damage after 10 days application of *B. Thuringiensis*there after two sprays each ofEconim 0.5% and NSKE 3% at 10 days interval*)*,M_2(Plethora 2 mL/L + Spraywell 1 mL/L, Coragen 0.33 mL/L + Neemark 1 % - 1 mL/L, and Tracer 0.375 mL/L + Nuvan 1 mL/L + Spraywell 1 mL/Lat 10 days interval starting from initiation of the pest), M_3(1st spray of NSKE 3% at initiation of pest then spray of Econim 0.5% and NSKE 3% at 10 days interval) and

M_4(No treatment for pest control was given in this module). All the treatments were compared in a "Randomized Block Design" replicated thrice. The soil of experimental field was sandy loam in texture with a pH 8.11. The soil was low in available nitrogen (180.69 kg ha^{-1}), medium in available phosphorus (27.32 kg P_2O_5 ha^{-1}) and rich in available potash (283.40 kg K_2O ha^{-1}). Observation were recorded at on week interval starting from fifth week after transplanting.

The important findings derived from theseinvestigations are summarized and concluded as under.

The effect of different treatment modules on meanpopulation of Diamondback moth revealed that all the threemodules were found to be effective in reducing larval populationof Diamondback moth as compared to control. Among differenttreatment modules, IPM module exhibited comparatively lowerlarval population (1.5/10 plants) and it was at par with botanicalinsecticides (1.7/10 plants) and sole chemical insecticides(1.87/10 plants). Further, the data on per cent leaf damaged byDiamondback moth larvae indicated that all the three modules *i.e.*lPM, sole botanical and sole chemical insecticides significantlyreduced leaf infestation as compared to untreated control(11.97%). The module comprising of sole botanical insecticidesrecorded comparatively lower leaf infestation (7.42%) and it wasat par with IPM (7.52%) as well as with sole chemical insecticides(8.13%).

While evaluating different treatment modules againstDiamondback moth, their effect on population of other pests,causing damage to cauliflower was also studied. The observationson mean population of aphid indicated that all the three moduleswere remained at par with each other. However, comparativelylower aphid population was recorded in module comprising ofsole botanical insecticides (1.35/leaf) followed by sole chemicalinsecticides (1.37/leaf) and IPM module (1.48/leaf). So far, theinfluence of different treatment modules on larval population of*Spodopteralitura*was concerned it showed that IPM module was significantly more effective (1.03/5 plants) than module comprising of sole botanical insecticides (1.77/5 plants) and sole chemicalinsecticides (1.29/5 plants) in reducing larval population of*S. litura*. However, in case of per cent leaf infested by *S.litura*larvae indicated that IPM module exhibited significantly lowerper cent leaf damage (10.67%) and it remained at par with solebotanical insecticides (11.12%). Further, sole botanicalinsecticides remained statistically at par with sole chemicalinsecticides (11.82%).

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