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INCIDENCE OF INSECT PESTS STUDIES WITH POPULATION DYNAMICS OF DIAMONDBACK MOTH (*PLUTELA XYLOSTELLA*) ON CABBAGE AND THEIR MANAGEMENT IN REWA DISTRICT

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ABSTRACT:

The experiment was carried out at Instructional Farm of JNKVV-College of Agriculture, Rewa (M.P) during Rabi season 2020-2021. Studies conducted on the population dynamics of Diamond back moth of Rewa district region showed its infestation of diamondback moth started in the 2nd week of February with a mean average population of 0.26 larvae per plant. The population increased gradually and its peak with a mean of 4.3 larvae per plant during last week of March (13th SW). Thereafter, population reduced gradually. The pest showed a positive and significant correlation with the maximum temperature and minimum temperature, whereas maximum relative humidity and rainfall had non-significant correlation and minimum relative humidity has negative significant correlation with the DBM population. The efficacy of new molecule of insecticides i.e., Chlorantraniliprole 18.5 SC, Fipronil 5% SC, Indoxacarb 14.5 SC, Spinosad 45 SC, Novaluron 10 EC, Emamectin benzoate 5 SG, Bt and Neem oil were compared with untreated control plot against diamond back moth *(Plutella xylostella)* Stroller two sprays of insecticide were done at 15 and 35 days after transplanting of the crop. The effect of insecticide was recorded on 3, 7, 10 and 15 days after the insecticide. Mean population of DBM of two sprays showed that Spinosad 45 SC proved to be most effective and superior over rest of the treatments and recorded the lowest population of DBM (0.55 larva/plant).The order of efficacy of insecticides was found in order T_4 (Spinosad 45 SC) > T_1 (Chlorantraniliprole 18.5 SC)
> T_6Emamectin benzoate > T_3 (Indoxacarb 14.5 SC) >T_2 (Fipronil 5% SC) > T_5 (Novaluron 10 EC) >T_8 (Bacillus thuringiensis 5% WP)> T_7 (Neem oil 0.15 %).The untreated control recorded maximum DBM larval population (3.35 larvae *I* plant). During field investigation total six species

of insects and six species of natural enemies have recorded in Cabbage. Resulting in the head yield 320.00 q/ha Spinosad 45 SC @ 100 g a.i./ha with maximum C:B ratio (1:21.31) was recorded from Chlorantraniliprole
18.5 SC treatment followed by Indoxacarb 14.5 SC (1:18.20).

KEYWORDS: DBM, Cabbage, Insects, Insecticides, Bio-pesticides, Natural enemies, Abiotic factors.

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INTRODUCTION:

Cabbage (*Brassica oleracea* L. var. capitata) is the most popular winter vegetables grown throughout India. It is used as salad, boiled vegetable and dehydrated vegetable as well as in cooked curries and pickles. Cabbage is also providing many health benefits. In fact, cabbage is rich in various phytonutrients and vitamins like vitamin A, C &K. These all are natural antioxidants, which help prevent cancer and heart disease inducing free radicals. The nutrition capacity of 100 g of cabbage provides 5.8 g of carbohydrates, 2.5 g dietary fiber, 1.3 g protein, 0 g fat, 36.6 mg vitamin C (44% of daily requirement), 76 mg vitamin K (72% of daily requirement) (USFDA,2006).The total area under cultivation of cabbage in India is 3.9 lakh ha With an annual production to the tone with productivity of 9037 metric tons. (Anonymous 2018).

Madhya Pradesh is having third posotion in Cabbage production. Cabbage area and production are respectively 889.74 ha and 686.91 MT (2017-18) in Madhya Pradesh. Mandla is a largest vegetables producing district. In Mandla 44,656.33 tonnes vegetable produced in the year of 2016-17. The cabbage covers 5,66,990 tonnes production. The major cabbage growing district of Madhya Pradesh is Shahdol, Betul, Chindwara, Ratlam, Balaghat, Jabalpur, Mandla, and Dindori. The yield of cabbage is adversely affected by many bottlenecks including insect, pest, disease environmental stresses, nutritional imbalance etc. Among them, insect pests, viz, tobacco caterpillar, *Spodoptera litura (Fab.)*, diamondback moth, *Plutella xylostella (*L.) Cabbage borer, *Helula undalis* (Fab.) cabbage looper, *Tricoplusia* ni Hub and aphid, *Lipaphis erysimi* (Kalt). Among the pest complex of cabbage, diamond back moth (*Plutella xylostella* Linn.) is the most destructive insect pest. Kumar et al., 1983) reported 52 percent losses in marketable yield of cabbage due to the infestation of *Plutella xylostella*.

Diamond back moth, *Plutella xylostella* belongs to the order Lepidoptera and family Plutellidae. It is a serious pest and has a great economic importance worldwide. Their caterpillars are the main culprits, feeding on the leaves of cabbage plants and also causing significant damage. In India, diamond back moth was first recorded on crucifer vegetables in 1914 (Fletcher 1914) and now it is distributed all over India wherever crucifers are grown and outbreak of *P. xylostella* was reported by (Ahmad *et al*. 2009) at Aligarh, India. It has been recognized as a cosmopolitan pest of cruciferous crops and it is well distributed and thrives under extremely varied climatic conditions prevailing in different parts of India and world being reported from 80 countries. 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.

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MATERIALS AND METHODS:

The experiment were conducted at Instructional farm of College of Agriculture, Rewa (M.P) during Rabi season 2020-2021. Cabbage was sown in 150 sq. meter area following the standard package and practices for this crop. Population dynamics and management of DBM of cabbage was studied on variety CLX 3945 by raising crop following all recommended agronomic practices. Meteorological data was collected from the Agro meteorology, College of Agriculture, Rewa, MP and the data were correlated with the population of DBM (*Plutella xylostella*). The crop will be sown in plots of size 15 m × 10 m with plant spacing 50 cm × 50 cm. Larval population of DBM were counted per plant on five randomly selected plant per plot from first appearance to till harvest of the crop. Meteorological parameter, viz., temperature, humidity and rainfall were recorded at weekly interval and correlations were worked out. The data on the larval count of each insect were subjected to statistical analysis and to find out the correlation between pest population and various meteorological parameters. Observations were recorded at weekly intervals. The observations on insect pest populations and natural enemies were recorded from five selected plant at fortnightly interval from the appearance of insect pests and natural enemies till harvesting of the crop. The cabbage field was studied on variety CLX 3945 by raising crop following the recommended package of practices with plant spacing of 50 × 50 cm with plot size 3 m × 2.5 m. The incidence of *P. xylostella* was observed from five randomly selected plants from three middle rows of each plot. The spray of insecticides was applied as soon as the pest incidence is noted. The first spray was done by knapsack sprayer at insect incidence on the crop and repeated after 15 days. Pre- treatment observation on pest population was undertaken one day before the application of the first spray by direct counting of *P. xylostella* larvae per five randomly pre- selected plants in each plot. Similar procedure was followed for post-treatment observation which was recorded at 3, 7, 10, 15 days after both the spray operations. The efficacy of new molecule of insecticides viz., Chlorantraniliprole 18.5 SC, Fipronil 5% SC, Indoxacarb 14.5 SC, Spinosad 45 SC, Novaluron 10 EC, Emamectin benzoate 5 SG, Bt and Neem oil, were compared with untreated control plot against the cabbage diamond back moth (*Plutella xylostella*).

The data were analyzed as per the experimental design to test the significant of the treatment. The data obtained on the number of insects were transformed to square root ($\sqrt{x+0.5}$) for the statistical analysis. Cabbage yield in different treatments were recorded per plot and same were converted to yield in q/ha.

Statistical Analysis:

The data on the populations of different larvae were subjected to statistical analysis as per RBD after transforming the square root transformation by using the following formula.

The square root transformation = $\sqrt{x+0.5}$ Where:

X = Population count.

Table 1 : Analysis of variance Table.

S No.	Source of Variance	D.F.	S.S.	M.S.S.	F. Values	
					Cal.	Tab.
1.	Block	r-1				
2.	Treatment	t-1				
3.	Error	(r-1) (t-1)				

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	Total	(r x t)-1				

The difference between the two means was subjected to further testing by computing critical difference at 5% probability level.

1. Standard error for treatment means:

It was calculated by following formula.

$$S.\ Em. \pm = \sqrt{\frac{EMS}{r}}$$

$$SEd = \sqrt{\frac{2 \times EMS}{r}}$$

Where,
EMS = Error means sum of square r = Number of replications S.Em = Standard error of mean

2. Critical difference: It was obtained by the following formula

$$C.D. = SEd \times t \text{ at } 5\ \%$$

Where
C.D. = Critical difference

Benefit Cost Ratio:

Gross return was calculated by multiplying total yield with the market price of the produce. Cost of cultivation and cost of treatment imposition was deducted from the gross returns, to find out net returns and cost benefit ratio by following formula

$$BC\ Ration = \frac{\text{Gross returns}}{\text{Total cost of cultivation}} \times 100$$

Where, B: C = Benefit Cost Ratio Grain yield

Yield was calculated under different treatments as per formula. Yield / ha = Factor x grain yield /

plot

RESULTS AND DISCUSSION:

Incidence of insect pests, natural enemies and population dynamics of diamond back moth and their management was studied in Cabbage under the condition of Rewa district during the *Rabi* season 2021 (Table 1 to 6).

Population dynamics of Diamondback moth (*Plutella xylostella*) in cabbage:

Diamondback moth (*Plutella xylostella*) was studied in Cabbage under the climatic condition of Rewa district during the Rabi season 2021.The incidence of diamondback moth started in the 4th standard week to 16th standard week have been presented separate Table 1 and along with the climatic data and the coefficient correlation value (r value).

With the view to provide a complete base for the management of insect pests, a quantitative estimation of population build up was carried out in relation to abiotic factors, viz. maximum and minimum, temperature, maximum and minimum relative humidity and rainfall under the prevailing agro-climatic conditions of the locality. The starting of infestation caused by diamond back moth was noted in the 8th standard week (i.e., Feb.20th /2021). With an average population of DBM 0.2 larvae / plant. A gradual increase in the pest population was noted up to 13th standard week (i.e., Last week of March 2021) with highest DBM was recorded 4.2 larvae per plants and the number of DBM was recorded 2.0 to 4.2 larvae per plants during entire month of March. Afterwards, population declined and an infestation of 0.8 larvae was noted in 16th SMW (2nd last week of April 2021).

The environmental conditions during the peak period of investigation indicated a mean rainfall of 00.00 mm, maximum relative humidity 56 % per week and minimum relative humidity 20.7% per week. Maximum and minimum temperature was recorded 37.640C and 16.900C, respectively per week. The weather parameters viz. maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall during the total period of mean incidence were 32.32°C, 12.46°C,
62.44 per cent, 29.04 per cent and 0.015 mm, respectively. The correlation coefficient between number of DBM per plants and total rainfall was worked out and was positive and non-significant correlated (r = 0.20)

The initiation of diamond back moth infestation was noted in the 8th standard week (i.e., Feb. 2nd last 2021). With an average population of diamond back moth 0.26 larvae
/ plant. The average weekly population of 0 to 0.53 larvae per plant during the month of February 2021.

Increased numbers of diamond back moth were observed during the month of February 2021. The maximum number of diamond back moth was recorded 4.3 larvae per plant (13th SMW) and the number of diamond back moth was recorded 0.53 to 4.3 larvae per plant during month of March. Thereafter the population of the pest started decreasing gradually during the 1st week of April 2021. Sharma et al., (2017) also reported that the population of diamond back moth infestation gradually reached the peak with 18.68 larvae / plant during Rabi, 2014 -15 and 2015-16 in the 14th SW.

The correlation studies delineates that the diamond back moth population was positive and

significantly regulated by maximum and minimum temperature (r = 0.75 & 0.81 respectively), whereas maximum relative humidity and rainfall had non-significant correlation and minimum relative humidity has negative significant correlation (r = - 0.58) with the diamond back moth population. Sahu et al., (2020) has also pointed out that the effect of abiotic parameters on Cabbage pest incidence revealed that temperature maximum and temperature minimum showed significant positive correlation (r= 0.58*, 0.58* respectively) and morning relative humidity showed significant negative correlation (r= -0.63**) with larval population. The present findings of the significant positive correlation of diamondback moth population with the maximum and minimum temperature were also reported by various workers (Venkateswarlu et al., 2011 & Singh et al., 2023).

Seasonal incidence of major insect pest of cabbage and their natural enemies Diversity of insect pests infesting Cabbage crop field:

The cultivar of six insect pests after noted were recorded during germination to harvesting of the crop (Table 2) in which Diamond back moth and Aphid showed great diversity in nature, Tobacco caterpillar showed medium diversity and Leaf eating caterpillar, flea beetle and Green sting bug showed less diversity in the field. The composition of Cabbage insect pests has been studied by various workers. The insect pests of economic importance have been recorded by various workers (Rai et al., 2014; Sarma et al., 2021).

Diversity of natural enemies of insect pests in cabbage:

Cabbage crop attracts large number of insect pests and their natural enemies (Table 3). The natural enemies help in restricting the population of potential pests to non- damaging level. The interference with the ecosystem particularly because of the misuse of pesticides can results in the destruction of these biotic agents and allows pests population to explode. The natural enemies of insect pests associated with cabbage were of diversified groups. The cultivar attracted six natural enemies in which lady bird beetle found effectively on aphid, Rove beetle found effectively on larvae of tobacco caterpillar and ground beetle effective of aphid and moth larvae. Predators recorded during the survey in cruciferous crop were comparable with the findings of several authors (Jalali et al., 2003; Agarwal et al., 2007; Sood, 2004).

Efficacy of novel insecticides and biopesticide for the management of diamondback moth (*Plutella xylostella*):

The efficacy of new molecules of insecticides against diamond back moth was studied under the climatic condition of Rewa district (Table 3 & 4) . In which Eight insecticides namely i.e. Chlorantraniliprole 18.5 SC, Fipronil 5% SC, Indoxacarb 14.5 SC, Spinosad 45 SC, Novaluron 10 EC, Emamectin benzoate 5 SG, Bt and Neem oil were evaluated against DBM following two application of insecticides spray at 15 days and 35 days after cabbage transplanting. The observations were recorded at 3, 7, 10 and 15 days after each spray along with the respective pre-count population.All insecticide ware found very effective and significantly superior over control. However, T_4 and T_1 (Spinosad 45 SC and Chlorantraniliprole 18.5 SC respectively) were best

among them. The Diamond back moth population count in this treatment recorded between between 1 to 1.73 larvae per plant in all the insecticide treatment plot as against control (2.53 larvae per plant).

However, after 7 and 10 days after treatment again insecticides were found significantly superior over untreated control in reducing the larval population of the pest, with diamond back moth population range 0.67 to 1.53 larvae per plant was noted in all the insecticide treated plots whereas in control plot 2.93 larvae per plant were recorded 7 days after and the population of diamond back moth varied between 0.53 to 1 larvae per plant in various insecticide treatments as against control (2.93 larvae per plant) was recorded 10 days after treatments. Here also Spinosad 45 SCproved superior with a reduction in the diamond back moth population to the extent of 0.53 larvae per five plants. T_4 (Spinosad 45 SC) > T_1(Chlorantraniliprole 18.5 SC) >T_6 (Emamectin benzoate 5 SG) >T_3(Indoxacarb 14.5 SC) >T_2 (Fipronil 5% SC) > T_5(Novaluron 10 EC) >T_8(Bacillus thuringiensis 5% WP)> T_7 (Neem oil 0.15 %). In case of second spray of insecticides Spinosad 45 SC again superior over rest of the treatment and all insecticide was found very effective and significantly superior over control.

Diamond back moth population range 0.87 to 1.8 larvae per plant was noted in all the insecticide treated plots whereas in control plot 4.33 larvae per plant were recorded 3 days after and the population of diamond back moth varied between 0.67 to 1.2 larvae per plant in various insecticide treatments as against control (3.60 per plant) was recorded 7 days after treatments.Fifteen day of treatments the population of diamond back moth varied between 0.27 to 0.73 larvae per plant. The effectiveness of these treatnments application was found in order T_4 (Spinosad 45 SC) > T_1 (Chlorantraniliprole 18.5 SC) >T_6 (Emamectin benzoate 5 SG)>T_3 (Indoxacarb 14.5 SC) >T_2 (Fipronil 5% SC) > T_5 (Novaluron 10 EC) >T_8 (Bacillus thuringiensis 5% WP) > T_7 (Neem oil 0.15 %). Dotasara et al. (2017) and Nikam *et al.,* (2014) also reported effectiveness of Spinosad against this pest, who observed the better efficacy of Spinosad against DBM.

Effect of insecticides/bio-pesticides on Cabbage yield:

The yield of cabbage an increase after the spray of insecticides (Table 6). The Spinosad 45 SC (T4) was recorded in the plot treated with highest yield of 320 Q/ha, which was significantly similar to the at par treatments viz. T1 (Chlorantraniliprole 18.5 SC) and T6 (Emamectin benzoate 5 SG) recorded a yield of 298 and 293.06 Q/ha, respectively. While, the lowest yield of 200.93 Q/ha was recorded from control plot. Among the treatments, Neem oil 0.15% (T7) recorded the lowest yield of 220.93 Q/ha. The order of yield (kg/ha) in various treatments was found as: T4 (Spinosad 45 SC) > T1 (Chlorantraniliprole 18.5 SC) > T6 (Emamectin benzoate 5 SG) > T3(Indoxacarb 14.5 SC) > T2 (Fipronil 5% SC) > T5 (Novaluron 10 EC) > T8 (*Bacillus thuringiensis* 5% WP) > T7 (Neem oil 0.15%) > T9 (Control).

The cost benefit ratio:

The cost benefit ratio of different insecticidal treatments against cabbage diamond back moth was calculated (Table 6), which divulge that maximum C:B ratio (1:21.31) was recorded from Chlorantraniliprole 18.5 SC (T1) treatment followed by Indoxacarb 14.5 SC (T3) (1:18.20), Emamectin benzoate 5 SG (T6) (1:17.43), Spinosad 45 SC (T4) (1:12.23), Fipronil 5% SC (T2) (1:8.26), Bt 5% WP (T8) (1:7.32), Novaluron 10 EC

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(T5) (1:5.40) and Neem oil 0.15% (T7) (1:2.51).

Table 1: Population of Diamondback moth in relation to temperature, relative humidity and rainfall during *Rabi* season 2020-21

Standard weeks /name week of month	Population	Max. temp. (^{0}C)	Min. temp. (^{0}C)	Max RH. (%)	Min RH (%)	Rainfall (mm)
04 (22 Jan. to 28 Jan.)	00	24.75	7.6	78.57	53.00	00.00
05 (29 Jan. to 04 Feb.)	00	24.24	5.55	74.14	43.28	00.00
06 (05 Feb. to 11 Feb.)	00	26.20	8.94	73.28	40.00	00.00
07 (12 Feb. to 18 Feb.)	00	28.88	10.10	73.85	35.71	00.00
08 (19 Feb. to 25 Feb.)	0.2	29.74	10.11	72.57	28.74	00.00
09 (26 Feb. to 04 Mar.)	0.6	34.12	12.84	61.57	21.42	00.00
10 (05 Mar. to 11 Mar.)	2.2	34.35	13.35	65.28	20.00	00.00
11 (12 Mar. to 18 Mar.)	2.6	33.61	15.04	64.14	25.14	00.20
12 (19 Mar. to 25 Mar.)	3.8	35.51	17.97	61.14	29.85	00.00
13 (26 Mar. to 01 Apr.)	4.2	37.64	16.90	56.00	20.71	00.00
14 (2 Apr. to 8 Apr.)	3.4	37.65	13.45	51.42	21.85	00.00
15 (9 Apr. to 15 Apr.)	2.2	34.33	14.67	44.14	20.57	00.00
16(16 Apr. to 22 Apr.)	0.8	39.14	15.44	35.57	17.24	00.00
Mean	1.54	32.32	12.46	62.44	29.04	0.015
Correlation coefficient (r value)	**1.00**	**0.74****	**0.82****	**-0.49**^{NS}	**-0.57***	**0.20**^{NS}

Table 2 : Qualitative composition of insect pests of cabbage during *Rabi* season 2020-21

S. No.	Common name	Scientific name	Family	Order	Damaging stage	Population level
1.	Diamondback moth	*Plustella xylostella* (L.)	Plutellidae	Lepidoptera	Caterpillar	High
2.	Leaf eating caterpillar	*Helicoverpa armigera* (Hub.)	Noctuidae	Lepidoptera	Caterpillar	Low

3.	Tobacco caterpillar	*Spodoptera litura* Fab.	Noctuidae	Lepidoptera	Caterpillar	Medium
4.	Flea beetle	*Phyllotrea Cruciferae*	Chrysomelidae	Coleoptera	Grubs and Adult	Low
5.	Green sting bug	*Nezara viridula*	Pentatomidae	Hemiptera	Nymph and Adult	Low
6.	Aphid	*Brevicorynebrass icae* (L.)	Aphididae	Homoptera	Nymph and Adults	High

Table 3 : Natural enemies recorded in diamond back moth during Rabi season 2020-21

S. No.	Common Name	Scientific Name	Order	Family	Host
1.	Dragon fly	*Ashna spp.*	Odonata	Aeshnidae	Aphids, thrips, Whitefly
2.	Damselfly	Coenagrion spp.	Odonata	Agrionidae	Aphids and whitefly
3.	Lady bird beetles	*Menochilus sexmaculatus Fabricius, Coccinella transversalis*	Coleoptera	Coccinellidae	Aphids
4.	Rove beetle	*Paederus fuscipes*	Coleoptera	Staphylinidae	Larvae of Bihar hairy caterpillar
5.	Hover flies	*Furcelleta Toxomerus geminetus*	Diptera	Syrphidae	Aphids, thrips
6.	Ground beetle	*Ophionea* spp.	Coleoptera	Carabidae	Aphids, moth larvae

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Table 4: Efficacy of different insecticides treatment against population of Diamond back moth during *Rabi* season 2021

Insecticides	Dosage g or ml a.i./ha	DBM larvae per plants First spray After Treatment					Mean
		Pre-count	3DAT	7DAT	10DAT	15DAT	
Chlorantraniliprole 18.5 SC	10	2.46 (1.72)	1.06 (1.25)	0.87 (1.17)	0.6 (1.17)	0.93 (1.19)	0.85 (1.16)
Fipronil 5% SC	40	2.2 (1.64)	1.53 (1.42)	1.2 (1.30)	0.8 (1.30)	1.2 (1.30)	1.18 (1.29)
Indoxacarb 14.5 SC	40	2.33 (1.68)	1.27 (1.33)	1.13 (1.28)	0.73 (1.28)	1.06 (1.25)	1.05 (1.24)
Spinosad 45 SC	100	2.6 (1.76)	1 (1.22)	0.67 (1.08)	0.53 (1.08)	0.8 (1.14)	0.75 (1.11)
Novaluron 10 EC	75	2.13 (1.62)	1.53 (1.42)	1.27 (1.33)	0.87 (1.33)	1.27 (1.33)	1.22 (1.31)
Emamectin benzoate 5 SG	10	2.13 (1.62)	1.13 (1.28)	0.93 (1.19)	0.67 (1.08)	1 (1.22)	0.92 (1.19)
Neem oil 0.15%	4.5	2.33 (1.68)	1.73 (1.49)	1.53 (1.42)	1 (1.42)	1.6 (1.45)	1.465 (1.4)
Bacillus thuringiensis 5% WP	25	2.2 (1.64)	1.67 (1.47)	1.33 (1.35)	0.93 (1.35)	1.4 (1.38)	1.33 (1.35)
Untreated check	-	2.4 (1.7)	2.53 (1.74)	2.93 (1.85)	2.93 (1.85)	3 (1.87)	2.85 (1.83)
SEm±		0.23	0.1	0.07	0.09	0.11	
CD at 5 %		NS	0.31	0.22	0.3	0.34	

*Figures in parentheses are $\sqrt{x+0.5}$ transformed values

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Table 5: Efficacy of different insecticides against population of Diamond back moth during *Rabi* season 2021

* Figures in parentheses are $\sqrt{X + 0.5}$ transformed values

Treatment	Insecticides	Dosage g or ml a.i./ha	Pre-count	DBM larvae per plant Second spray after Treatment				Mean
				3DAT	7DAT	10DAT	15DAT	
T_1	Chlorantraniliprole 18.5 SC	10	1.60 (1.45)	1.00 (1.22)	0.73 (1.11)	0.47 (0.98)	0.33 (0.91)	0.67 (1.08)
T_2	Fipronil 5% SC	40	2.00 (1.58)	1.67 (1.47)	1.00 1.22)	0.73 (1.11)	0.53 (1.01)	0.98 (1.22)
T_3	Indoxacarb 14.5 SC	40	1.87 (1.54)	1.53 (1.42)	0.93 (1.19)	0.67 (1.08)	0.47 (0.98)	0.9 (1.18)
T_4	Spinosad 45 SC	100	1.53 (1.42)	0.87 (1.17)	0.67 (1.08)	0.4 (0.94)	0.27 (0.88)	0.55 (1.02)
T_5	Novaluron 10 EC	75	2.20 (1.64)	1.73 (1.49)	1.06 (1.25)	0.8 (1.14)	0.6 (1.05)	1.05 (1.24)
T_6	Emamectin benzoat e 5 SG	10	1.73 (1.49)	1.06 (1.25)	0.8 (1.14)	0.6 (1.04)	0.4 (0.95)	0.71 (1.1)
T_7	Neem oil 0.15%	4.5	2.33 (1.68)	1.8 (1.52)	1.2 (1.30)	0.87 (1.17)	0.73 (1.11)	1.15 (1.28)
T_8	Bacillus thuringiensis 5% WP	25	2.4 (1.70)	1.73 (1.49)	1.13 (1.28)	0.8 (1.14)	0.67 (1.08)	1.08 (1.26)
T_9	Untreated check	-	3.67 (2.04)	4.33 (2.19)	3.6 (2.02)	2.93 (1.85)	2.53 (1.74)	3.35 (1.96)
	SEm±		0.14	0.08	0.11	0.1	0.11	
	CD at 5 %		0.44	0.23	0.34	0.31	0.33	

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Table 6: Effect of different insecticides sprays on the economics of the cabbage diamond back moth.

S. No	Treatments	Insecticides	Dosage ml/g a.i./ha	Average Yield (Q/ha)	Additional yield over control (Q/ha)	% yield increased	Gross monetary return due to treatment** (Rs./ha)	Protection cost for 2 sprays* (Rs./ha)	Net return due to treatments (Rs./ha)	C:B ratio
1	T_1	Chlorantraniliprole 18.5 SC	10	298	97.07	48.31	97067.00	2960	94107.00	1:21.31
2	T_2	Fipronil 5% SC	40	252.4	51.47	25.61	51467.00	3875	47592.00	1:8.86
3	T_3	Indoxacarb 14.5 SC	40	284.933	84.00	41.80	84000.00	3850	80150.00	1:18.20
4	T_4	Spinosad 45 SC	100	320	119.07	59.26	119067.00	5470	113597.00	1:12.23
5	T_5	Novaluron 10 EC	75	248.933	48.00	23.89	48000.00	4721	43279.20	1:5.40
6	T_6	Emamectin benzoate 5 SG	10	293.067	92.13	45.85	92134.00	8501	83633.25	1:17.43
7	T_7	Neem oil 0.15%	4.5	220.933	20.00	9.95	20000.00	4500	15500.00	1:2.51
8	T_8	Bacillus thuringiensis 5% WP	25	230	29.07	14.47	29067.00	7000	22067.00	1:7.32
9	T_9	Untreated check	-	200.933						-
	SEm±			0.03	-	-	-	-	-	-
	CD at 5 %			0.10	-	-	-	-	-	-

*Protection cost for 2 sprays:

Labour charge = Rs 2500 Knapsack hiring = Rs 500 Cost of insecticides used for treatment:

Chlorantraniliprole 18.5 SC = Rs 13500 /lit, Fipronil 5% SC = Rs 1388 /Kg, Indoxacarb 14.5 SC = Rs 2500 /lit, Spinosad 45 SC = Rs 13335 /lit., Novaluron 10 EC = Rs 3000 /lit, Emamectin benzoate 5 SG = Rs 5000 /lit, Neem oil 0.15% = Rs450 /lit, Bacillus thuringiensis 5% WP = Rs 495 /lit.

CONCLUSION:

The activity of diamond back moth in cabbage was recorded from February to April 2021. The maximum population (4.2 larvae per plant per week) was observed in the last week of March 2021 and thereafter fall in population count was observed. The pest showed a positive and significant correlation with the maximum temperature and minimum temperature, whereas maximum relative humidity and rainfall had non- significant correlation and minimum relative humidity has negative significant correlation with the diamond back moth population. The seasonal incidence studies indicated that there were six insect pests recorded during the entire cropping season in cabbage along with the six natural enemies, among them diamond back moth, aphid is

the major insect pest. The efficacy of Spinosad 45 SC proved to be most effective and superior over rest of the treatments and recorded the lowest population of DBM (0.55 larva/plant). The order of efficacy of insecticides was found in order T4 (Spinosad 45 SC) > T1 (Chlorantraniliprole 18.5 SC) > T6 Emamectin benzoate > T3 (Indoxacarb 14.5 SC) > T2 (Fipronil 5% SC) > T5 (Novaluron 10 EC) >T8 (Bt 5% WP) > T7
(Neem oil 0.15 %). The head yield 320.00 q/ha Spinosad 45 SC @ 100 g a.i./ha with maximum C:B ratio (1:21.31) was recorded from Chlorantraniliprole 18.5 SC treatment.

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