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Bio-efficacy of newer insecticides against the lepidopteran insect-pests in cabbage

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Abstract
Diamondback moth (DBM), *Plutella xylostella* and (CB), *Pieris brassicae* are serious insect pests on cabbage. Experiments were conducted to study the effectiveness of insecticides against these lepidopteran pests in cabbage cultivation. The efficacy of insecticides namely, chlorantraniliprole, emamectin benzoate, spinosad, indoxacarb, quinalphos, fenvelerate, and novaluron were studied against DBM and CB under field conditions at ICAR-IIVR, Regional Research Station, Sargatia, Kushinagar, India. All the insecticides were found effective in reducing these lepidoptetran insect pests over the untreated control. The reduction of DBM after the application of chlorantraniliprole, indoxacarb, spinosad and emamectin benzoate were observed significantly superior over other insecticides and untreated control at all the interval of observation giving 78.54, 89.91, 86.72 and 74.88 percent reduction over control. Similarly, the reduction of CB after the application of chlorantraniliprole, indoxacarb, spinosad and emamectin benzoate were observed significantly superior over other insecticides and untreated control at all the interval of observation giving 92.12, 84.97, 75.35 and 79.00 percent reduction over control. The insecticides like quinalphos, novaluron and fenvalerate were found relatively less effective causing 56.82, 59.33 and 59.93 percent reduction over control of DBM and 67.41, 65.18 and 51.76 percent reduction over control of CB. Therefore, we recommend the use of newer molecules cyantraniliprole and flonicamid as an alternative option for effective management of the diamondback moth and cabbage butterfly in cabbage.

Keywords: *Plutella xylostella*, *Pieris brassicae*, cabbage, bioefficacy, indoxacarb, chlorantraniliprole, spinosad, emamectin benzoate

Introduction

Cabbage (*Brassica oleracea* var. capitata L.) is one of the widely cultivated species of the Brassicaceae family, which is generally consumed as a leafy green vegetable. Although low in calories, cabbage is a good source of dietary fibre, vitamins and minerals. It also stands out for having high concentrations of calcium, iron, iodine, potassium, sulphur and phosphorus. Cabbage is a remarkable nutritional remedy for battling the dreaded disease of cancer because of its anti-cancer features (USDA 2009) [16]. Despite the economic as well as nutritional importance of cabbage, the major bottleneck in cabbage production is the qualitative as well as quantitative losses incurred by the serious attack of the insect pests (Alula and Tesfaye 2021) [2]. The diamondback moth (DBM) *Plutella xylostella* DBM and Cabbage butterfly, *Pieris brassicae* (Linn.) CB have been reported as the major insects that are major biotic stresses in the production of cabbage responsible for 52% and 40% yield losses respectively, in India (Krishnamoorthy, 2004; Ali and Rizvi, 2007) [12, 1].

Even while there are environmentally beneficial and long-lasting insect control methods, such as host plant resistance (HPR) (Divekar *et al*. 2019a, b) [6, 7], plant secondary metabolites (Divekar *et al*. 2022a) [4], bio-control agents (Dukare *et al*. 2021) [9] and defence proteins (Divekar *et al*. 2022b) [8], synthetic agrochemicals are the farmers first preference. Due to the lack of access to sustainable management methods, small-scale farmers are finding it difficult to deal with the pests' mounting threat (Divekar *et al*., 2022c) [5].

The overuse of insecticides, the rapid reproduction of insects and the regular access to host plants caused new challenges such as insecticide resistance development and multiple pest infestations in cabbage. To solve the problem of insecticide resistance and manage multiple pest infestations, there is an alarming situation to search a highly effective and environmentally safer option that can be used individually or in combination safely to control DBM and CB in cabbage.

With this brief overview, the present study was carried out to evaluate the effectiveness of newer insecticides on cabbage under field conditions.

Materials and Methods

Field efficacy of insecticides against DBM and CB

The field experiment was carried out with the cultivation of cabbage variety Golden Acre during the Spring 2019 season at Regional Research Station, Sargatia, Karanpatti, Kushinagar. The field studies were done in a randomized block design (plot size: 4 m×3 m) with nine treatments including untreated control and the same set of experiments was repeated three times. The crop was grown according to the standard recommended agronomic practices, with the exception of protective measures. The experimental treatment details are as given in Table 1.

In both seasons, 35-day-old cabbage seedlings were transplanted. Insecticidal spray treatments were applied 40, 50 and 60 days after transplantation (DAT) at the cross of the ETL of DBM (Rai *et al*. 2014) [15] and CB (Rai *et al*. 2014) [15]. The number of insect pests before treatment was noted one day prior to insecticide treatment application. Larval counts of DBM and CB were recorded visually on the first, third, fifth, seventh, and ninth days following each spraying from the top and bottom of the entire plant on five randomly chosen plants. The Henderson and Tilton (1955) [11] formula was used to determine the percentage of pest population reduction compared to control

Result and Discussion

Efficacy of insecticides against DBM and CB

The results of the bio efficacy of selected insecticides against diamondback moth *P. xylostella* in cabbage are presented in Table 2. The pre-treatment number for the DBM population was not significant and ranged from 7.33 to 9.33 (F=3.42, p=0.26). The treatments were found significantly different in terms of mean DBM population after insecticide spray application (F = 224.31, p<0.001) (Table 2). Indoxacarb 14.5% SC and Spinosad 45% SC were found highly effective against DBM reducing the population to 1.0 and 1.53 per plant and registered 89.91 and 86.72 percent reduction over control of DBM larval population. Chlorantraniliprole 18.5% SC, Emamectin benzoate 5% SG and lambda cyhalothrin were also effective in managing the DBM population and reduced the population to the tune of 2.13, 2.40, 2.60 larvae per plant and recorded 78.52, 74.88 and 75.20 percent reduction over control, respectively. Insecticides namely quinalphos 25% EC, novaluron 10% EC and fenvalerate 20%EC were found relatively less effective against DBM larval population reducing the population to 3.87, 3.47 and 3.67 giving 56.82, 59.33 and 59.93 percent reduction over control, respectively (Table 2).

The results of the bioefficacy of selected insecticides against the cabbage butterfly *Pieris brassicae* are shown in Table 3. The pre-treatment number for the CB population was not significant and ranged from 8.20 to 10.27 (F=2.34, p=0.46). Insecticidal treatment were significantly different in terms of mean CB population after insecticide spray application (F = 164.4, p<0.001) (Table 3). Chlorantraniliprole 18.5% SC and Indoxacarb 14.5% SC were found highly effective against CB reducing the population to 0.80 and 1.53 per plant and registered 92.12 and 84.97 percent reduction over control of CB larval population. Emamectin benzoate 5% SG and Spinosad 45% SC were also effective in managing the CB population and reduced the population to the tune of 1.8 and 2.07 larvae per plant and recorded 79.0 and 75.35 percent reduction over control, respectively. Insecticides namely fenvalerate 20% EC, quinalphos 25% EC, lambda cyhalothrin 5% EC and novaluron 10% EC were found relatively less effective against CB larval population reducing the population to 4.6, 2.93, 1.53 and 3.73 giving 51.76, 67.41, 68.36 and 65.18 percent reduction over control, respectively (Table 3)

In comparison to the untreated control, it became apparent that all pesticides were effective at lowering the DBM and CB population. The results showed that chlorantraniliprole 18.5% SC, indoxacarb 14.5% SC, emamectin benzoate 5% SG and spinosad 45% SC were effective against both cabbage lepidopteran pests under field conditions. However, the insecticides namely, fenvalerate 20% EC, quinalphos 25% EC, lambda-cyhalothrin 5% EC and novaluron 10% EC were comparatively not so effective at reducing DBM and CB in cabbage.

Chlorantraniliprole 18.5 SC @ 30 g a.i. ha-1 has been shown to be the most efficient at lowering the larval DBM population in cabbage (Patra *et al*., 2015) [13]. Insecticides namely spinosad, emamectin benzoate, indoxacarb and chlorantraniliprole have been shown to be effective for the control of DBM, *P. xylostella* and CB, *P. brassicae* in cabbage under field conditions (Divekar *et al*., 2022) [5]. Newer insecticides, namely chlorantraniliprole 18.50 SC and flubendiamide 20 WG caused a population reduction of greater than 95% compared to the untreated control, followed by emamectin benzoate 5 SG against DBM in cauliflower. However, quinalphos 25 EC and chlorpyriphos 20 EC were observed to be less efficient in the management of DBM (Beena and Selvi, 2022) [3].

A significantly higher percentage larval reduction of DBM larvae compared to control was recorded in plots treated with chlorantraniliprole (91.30%), followed by spinosad (87.55%) and flubendiamide (86.61%). On the other hand, insecticides such as quinalphos 25% EC and triazophos 40% EC proved to be the least effective, resulting in a 67.52 and 63.59 percent reduction in DBM, respectively, compared to the untreated control (Sawant and Patil, 2018) [17]. The effectiveness of indoxacarb (75 g a.i./ha) and chlorfenapyr (100 g a.i./ha) as treatments for lowering the diamondback moth larval population was also proven (Patra *et al*., 2017) [14]. The insecticides emamectin benzoate (80.31%) and spinosad (72.44%) were responsible for better crop protection against cabbage butterfly *Pieris brassicae* versus control in cabbage (Gautam *et al*., 2022) [10].

Table 1: Insecticide selected for the bio-efficacy studies against DBM and CB in cabbage

Sr. No.	Description	Dose (g a.i./ha)	Trade Name	Manufacturer
1	Novaluron 10 EC	75	Rim on	Indofil Industries Ltd
2	Chlorantraniprole 18.5 SC	10	Coragen	Dupont
3	Indoxacarb 14.5 SC	40	K- Indox	Katyayani Organics
4	Lambda Cyhalothrin 5 EC	15	Karate	Syngenta India Ltd
5	Spinosad 45 SC	15	Tracer	Corteva
6	Emamectin Benzoate 5 SG	10	Egao	IFFCO-MC
7	Quinalphos 25 EC	300	Krush	Biostadt India Limited
8	Fenvalerate 20 EC	75	Tatafen	Rallis India Ltd

Table 2: Effect of insecticides on the larval population of diamondback moth, *P. xylostella* in cabbage

Treatments	Dose g a.i./ha	PTC	Average DBM population*	PROC
Novaluron 10 EC	75	7.33±0.37	3.47±0.24	59.33±3.60
Chlorantraniliprole 18.5 SC	10	8.27±0.07	2.13±0.07	78.54±0.11
Indoxacarb 14.5 SC	40	8.07±0.35	1.00±0.20	89.91±1.47
Lambda Cyhalothrin 5 EC	15	8.73±0.24	2.60±0.23	75.20±2.21
Spinosad 45 SC	15	9.23±0.48	1.53±0.18	86.72±0.81
Emamectin Benzoate 5 SG	10	8.00±0.18	2.40±0.12	74.88±2.29
Quinalphos 25 EC	300	7.47±0.41	3.87±0.18	56.82±1.21
Fenvalerate 20 EC	75	7.60±0.12	3.67±0.24	59.93±1.81
Control	-	8.93±0.18	16.73±0.24	-
F	-	3.42	224.31	-
P	-	0.26	<0.001	-

PTC-Pre-treatment Count, PROC-percent reduction over control, * Mean DBM larval population after three sprays, Data are means of three replications.

Table 3: Effect of insecticides on the larval population of cabbage butterfly, *P. brassicae* in cabbage

Treatments	Dose g a.i./ha	PTC	Average Pieris population*	PPOC
Novaluron 10 EC	75	10.27±0.74	3.73±0.18	65.18±1.08
Chlorantraniliprole 18.5 SC	10	9.80±0.96	0.80±0.12	92.12±1.27
Indoxacarb 14.5 SC	40	9.73±0.48	1.53±0.18	84.97±1.32
Lambda Cyhalothrin 5 EC	15	8.87±0.18	2.60±0.12	68.36±0.95
Spinosad 45 SC	15	8.07±0.18	2.07±0.18	75.35±2.56
Emamectin Benzoate 5 SG	10	8.20±0.35	1.80±0.12	79.00±0.68
Quinalphos 25 EC	300	8.67±0.48	2.93±0.24	67.41±3.35
Fenvalerate 20 EC	75	9.13±0.52	4.60±0.23	51.76±1.74
Control	-	9.40±0.50	16.80±0.40	-
F	-	2.34	164.4	-
P	-	0.46	<0.001	-

PTC-Pre-treatment Count, PROC-percent reduction over control, * Mean CB larval population after three sprays, Data are means of three replications.

Conclusion

Newer insecticides molecules namely chlorantanilipole 18.5% SC, Indoxacarb 14.5% SC Emamectin benzoate 5% SG, Spinosad 45% SC were showing significantly higher reduction of DBM and CB larval population over untreated control. Quinalphos 25% EC, novaluron 10% EC, and fenvalerate 20% EC were found least effective against the lepidopteran pest complex of cabbage under field condition. Therefore, we recommend the application of chlorantraniliprole, indoxacarb, emamectin benzoate and spinosad either singly or in combination for effective management of the lepidopteran pest's diamondback moth and cabbage butterfly in cabbage ecosystem.

Author Contributions

Experiment Design and planning: PAD; Data analysis: PAD, MC; Experimentation: PAD, MK and SKP; Manuscript draft preparation: PAD and SKP; writing review and editing: PAD, MC and VS; supervision: MC, VS. All authors have read and agreed to the published version of the manuscript.

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