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Laboratory evaluation of chitin synthesis inhibitors on cabbage leaf webber, *Crocidolomia binotalis* (Zell)

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Abstract
Bio-efficacy of chitin synthetic inhibitors on cabbage leaf webber, *Crocidolomia binotalis* (Zell) were evaluated by using leaf dip bioassay method under laboratory condition during 2018-19. The study revealed that diflubenzuron 25 WP at 0.011 percent, novaluron 10 EC at 0.021 percent and buprofezin 25 SC at 0.019 percent concentrations (LC_{50}) caused 50 percent mortality on 3rd instar larvae. In treatment, larvae showed morphogenic deformities such as larval-pupal intermediates, deformed larvae etc. and the results of experiment done on one day old pupae, revealed that diflubenzuron 25 WP at 0.015 percent, novaluron 10 EC at 0.018 percent and buprofezin 25 SC at 0.017 percent concentrations (LC_{50}) caused 50 percent pupal mortality and reduction in pupal size. Emerged adults from the treated pupae were with morphological deformities like crippled and wrinkled wings, reduced antennae and reduction in size.

Keywords: Cabbage, efficacy, CSI, cabbage leaf webber, LC_{50}

Introduction
Cabbage, *Brassica oleracea* L. var. *capitata* is very important cruciferous vegetable crop grown in India. Among the different cabbage growing countries, India stands second in production after China. Total cabbage production accounts to 8,971thousand metric tons, in India with an average productivity of 18.89 metric tons per hectare (NHB, 2017) [6]. The major cabbage growing states in India are Uttar Pradesh, Odisha, Bihar, Assam, West Bengal, Maharashtra, Tamil Nadu and Karnataka.

Cabbage is very important vegetable crop grown for its nutritional and medicinal importance. Cabbage crop helps in alleviation of symptoms associated with gastrointestinal disorders (gastritis, peptic and duodenal ulcers, irritable bowel syndrome) as well as in treatment of wounds and mastitis (Rokayya *et al.*, 2013) [9]. It is a rich source of calcium, iron, magnesium, sodium, potassium, phosphorus vitamin A, vitamin C, carbohydrate and dietary fibers.

The production of cabbage in India is being affected by various biotic and abiotic factors. Among various biotic factors insect pests plays important role. Among various insect pests of cabbage Diamond Back Moth (DBM), *Plutella xylostella* is very important pest around the world 0.52 percent yield loss due to diamond back moth, *Plutella xylostella* (L) which is the most notorious pest (Krishnamurthy A., 2004) [4] and Reddy and Ali (1997) [8] observed 37.2 to 81.8 percent yield loss due to infestation by cabbage leaf webber, Dhir *et al,* (1992) [1].

Frequent usage of synthetic insecticides for pest management has led environmental pollution, disturbed the ecosystem and also aggravated the build-up of resistance in insect against various insecticides. Hence, there is more need to give emphasis on use of non-chemical management approaches including behavior modifying chemicals for pest management. One of these behavior modifying chemicals are chitin synthesis inhibitor (CSI).

Chitin synthesis inhibitors (CSI) do not favor the production of chitin in insect body wall. As a result of which the body wall becomes fragile in immature stage and more susceptible to moisture loss resulting in death. Laboratory experiment was conducted to check the bio efficacy of various CSI's against cabbage leaf webber, *Crocidolomia binotalis* (Zell).

Materials and Methods
The present experiment was carried out during 2018-2019. Crucifer leaf webber *Crocidolomia binotalis* (Zell) was mass reared in the laboratory of Department of Entomology, collage of agriculture OUAT, Bhubaneswar.

Crucifer leaf webber, egg masses and caterpillars were collected from unsprayed plots of cabbage field maintained at Central Farm of OUAT, Bhubaneswar.

Field collected eggs were kept in Petri plates for hatching. Neonate larvae were transferred with the help of fine camel hair brush to tender cabbage leaves. The petioles of the leaves were inserted into small plastic bottles containing water to prevent the drying up of the leaves. Grown up larvae were transferred to plastic jars, in which the cabbage leaves were kept and covered with muslin cloth. Leaves were changed once in two days for early instars and daily for later instar. After the formation of pupae; they were transferred to an adult emergence cage. Ten percent sugar solution was served as adult food in small vial with cotton and fresh cabbage leaves were provided for egg laying. Egg masses were collected every day and were kept in plastic jars for hatching. First and second instar larvae were reared in small plastic containers on fresh cabbage leaves and cabbage leaves were provided twice a day. As the caterpillars grew, they were transferred to slightly bigger containers.

Bioassay test

Leaves were collected from untreated cabbage field and were cleaned by using water, these leaves were cut into medium sized circular leaf disc. These leaf discs were dipped in different CSI concentration and kept for shade dry (Tabashnik and Cushing., 1987) [10]. Twenty larvae of third instar were released on each leaf and container was covered with muslin cloth using a rubber band. Each concentration was replicated thrice.

One day old pupae of test insect were taken and dipped into various concentrations of CSI's for 2 minute (20 numbers per replication) and their mortality at 24 hour interval up to 5 days was recorded. There were a total of 3 replications.

Statistical analysis

The data generated from various bioassay studies were subjected to necessary Probit analysis (Finny, 1971) [2] to find out LC_{50} for various test materials with help of SPSS software.

Results

Bioassay test on 3rdintar larva of crucifer leaf webber

The results of laboratory bioassay test carried on 3rd instar larvae of *Crocidolomia binotalis* through leaf dip method at 5 different concentrations of diflubenzuron 25 WP along with control is depicted that at 0.010 % concentration and after 120 hours of exposure there was 46.66 percent mortality was noticed which was nearly 50% of total larval population (Table 1). The dosage mortality responses represented in Table 2 revealed the LC_{50} of compound against 3rd instar larvae was 0.0110% with a fiducial limit of 0.0108 and 0.0112. The regression equation observed was Y=4.4+2.24x.

The observations recorded in Table 1 depicted that 51.66% mortality of 3rd instar larvae of *Crocidolomia binotalis* was observed after 120 hours of exposure of novaluron 10 EC at 0.015% concentration which was little above 50% of total larval population. The LC_{50} value of novaluron 10 EC against 3rd instar larvae was 0.021 percent with a fiducial limit of 0.013 and 0.026. The regression equation was found to be Y=3.1+1.65x (Table 2).

It was observed that after 120 hours of exposure of buprofezin 25 SC at 0.015% concentration for 120 hours, 51.66% mortality of 3rd instar larval population of *Crocidolomia binotalis* was noticed which was little above 50% of total larval population (Table 1). The LC_{50} of buprofezin 25 SC against 3rd instar larvae was 0.019 percent with a fiducial limit of 0.014 and 0.022. The regression equation was estimated to be Y=3.644+2.13x (Table 2).

Bioassay test on one day old pupae of *Crocidolomia binotalis*

The result of bioassay test conducted on pupae of *Crocidolomia binotalis* revealed that at 0.015 concentration of diflubenzuron 25 WP there was 49.99% mortality was observed which was very close to 50% of total pupal count (Table 3) and LC_{50} of 0.015 percent were noticed with a fiducial limit of 0.012 and 0.017. The regression equation was observed to be Y= 3.93+1.8x (Table 4).

The data in the Table 3 revealed that at 0.015 percent concentration of novaluron 10 EC, 48.33% mortality of pupae was observed which was nearer to the 50% of total pupal count. The LC_{50} of novaluron 10 EC, observed was 0.018 percent with a fiducial limit of 0.014 and 0.022. The regression equation was found to be Y=4.07+2.08x (table 4).

The obtained data from table 3 and 4 inferred that at 0.015 percent concentration of buprofezin 25 SC, 48.33% mortality was noticed which was nearer to the 50% and LC_{50} of buprofezin 25 SC recorded was 0.017 percent with a fiducial limit of 0.012 and 0.020. The regression equation was estimated to be Y= 4.44+2.35x.

The study revealed that diflubenzuron 25 WP at 0.015 percent, novaluron 10 EC at 0.018 percent and buprofezin 25 SC at 0.017 percent (LC_{50}) caused 50 percent pupal mortality and reduction in pupal size. Emerged adults were deformed with crippled and wrinkled wings; reduced antennae and reduction in size were also observed at various concentrations of CSIs which can be visualized from the photographs (Fig-6).

Discussion

Bioassay test through leaf dip method with all CSIs under study at 5 different concentrations were under taken against 3rd instar larvae and one day old pupae of crucifer leaf webber and results have been presented from Table 1 and 4.

The study revealed that diflubenzuron 25 WP at 0.011 percent, novaluron 10 EC at 0.021 percent and buprofezin 25 SC at 0.019 percent (LC_{50}) caused 50 percent mortality in 3rd instar larvae. The treated larvae also exhibited morphogenic deformities like larval-pupal intermediates and deformed larvae etc. at various concentrations of CSIs, which can be visualized from the photographs (Fig-1 and 4). A study conducted on pupae reveled diflubenzuron 25 WP at 0.015 percent, novaluron 10 EC at 0.018 percent and buprofezin 25 SC at 0.017 percent (LC_{50}) caused 50 percent pupal mortality and reduction in pupal size. Emerged adults from treated pupae were with deformities like crippled and wrinkled wings, reduced antennae and reduction in size were also observed at various concentrations of CSIs which can be visualized from the photographs (Fig-2, 3, 5 and 4). Rath (1985) [7] studied the efficacy of diflubenzuron against *Crocidolomia binotalis*. Similarly, Murty (1997) [5] also studied the efficacy of diflubenzuron against *Crocidolomia binotalis*. Gouda *et al*. (2006) [3] studied that novaluron, flufenoxuron and lufenuron were also effective against crucifer leaf webber and proved superiority over neem oil. The present finding derived ample support from the above findings.

Table 1: Effect of chitin synthesis inhibitors on 3rd instar larvae of *Crocidolomia binotalis* (Zell) in bioassay test (leaf dip method

Concentration of chemical	Number of larvae treated	Diflubenzuron 25 WP		Novaluron 10 EC		Buprofezin 25 SC	
		Total mortality%	Corrected mortality%	Total mortality%	Corrected mortality%	Total mortality%	Corrected mortality%
0.005	60	25.00	25.00	28.33	28.33	20.00	20.00
0.010	60	46.66	46.66	35.00	35.00	28.33	28.33
0.015	60	55.00	55.00	51.66	51.66	51.66	51.66
0.020	60	65.00	65.00	61.66	61.66	58.33	58.33
0.025	60	86.66	86.66	71.66	71.66	75.00	75.00
Control	60	-	-	-	-	-	-

Table 2: Dosage mortality response of chitin synthesis inhibitors against 3rd instar larvae of *Crocidolomia binotalis* (Zell) in bioassay test (leaf dip method)

Insecticide	Hours After Exposure	LC_{50}	Chi square	Regression Equation	Fiducial limit at LC_{50}	
					Lower	Upper
Diflubenzuron 25 WP	120h	0.011	4.97	Y=4.4+2.24x	0.0108	0.0112
Novaluron 10 EC	120h	0.021	1.168	Y=3.1+1.65x	0.013	0.026
Buprofezin 25 SC	120h	0.019	1.072	Y=3.644+2.13x	0.014	0.022

Table 3: Effect of chitin synthesis inhibitors on 1day old pupae of *Crocidolomia binotalis* (Zell) in bioassay test (pupal dip method)

Concentration of chemical	Number of pupae treated	Diflubenzuron 25 WP		Novaluron 10 EC		Buprofezin 25 SC	
		Total mortality%	Corrected mortality %	Total mortality%	Corrected mortality%	Total mortality%	Corrected mortality %
0.005	60	28.33	25.86	26.66	26.66	20.00	20.00
0.010	60	38.33	36.20	35.00	35.00	35.00	35.00
0.015	60	51.66	49.99	48.33	48.33	48.33	48.33
0.020	60	78.33	77.58	73.66	73.66	58.33	58.33
0.025	60	86.66	85.97	80.00	80.00	66.66	66.66
Control	60	03.33	-	-	-	-	-

Table 4: Dosage mortality response of chitin synthesis inhibitors against 1 day old pupae of *Crocidolomia binotalis* (Zell) in bioassay test (pupal dip method)

Insecticide	Hours After Exposure	LC_{50}	Chi square	Regression Equation	Fiducial limit at LC_{50}	
					Lower	Upper
Diflubenzuron 25 WP	120h	0.015	1.221	Y=3.93+1.8x	0.012	0.017
Novaluron 10 EC	120h	0.018	1.627	Y=4.07+2.08x	0.014	0.022
Buprofezin 25 SC	120h	0.017	0.794	Y=4.44+2.35x	0.012	0.020

Figures showing morphological deformities in larvae, pupae and adults of *Crocidolomia binotalis*

Fig 1: Morphological deformities in larvae, pupae and adults of *Crocidolomia binotalis* due to treatment of chitin synthesis inhibitors. (1) Normal last instar larva. (2) Normal pupae. (3) Normal adult. (4) Larval-pupal intermediates. (5) Abnormal pupae. (6) Deformed adult.

Conclusion

The results of present study revealed that, diflubenzuron 25 WP was found as the best treatment among all the chitin synthesis inhibitors tested against larvae and pupae of cruciferous leaf webber which is followed by novaluron 10 EC and buprofezin 25 SC. Even emerged adults from the treated pupae were with the morphological deformities because of poor deposition of cuticle. Hence, being ecofriendly and effective non chemical pest management approach, chitin synthesis inhibitors are effectively used for pest management

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