Website : www.asthafoundation.in
Progressive Research : An International Journal
Vol 17 (2) : 104-107 (July-2022), Print ISSN : 0973-6417, Online ISSN : 2454-6003
Society for Scientific Development in Agriculture and Technology, Meerut (U.P.) India

Efficacy of Insect Growth Regulators as Grain Protectants of Stored Chickpea against *Callosobruchus chinensis* L.

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Abstract

In the present study, nine insect growth regulators (IGRs), *viz*., diflubenzuron 25 WP, novaluron 10 EC, lufenuron 5.4 EC, pyriproxyfen, buprofenzin 25 SC, neem oil, NSKE, deltamethrin 2.8 EC and azadirachtin were evaluated against the adults of pulse beetle, *Callosobruchus chinensis* (L.) in chickpea. Sterilized and conditioned chickpea grain (250 g) was treated with different dosages of insect growth regulators. Adult emergence was observed at 24 hours, 60, 120, 180 and 240 days after treatment. Adult emergence was nil at neem oil 1.0%, NSKE 5.0% and azadirachtin 15000 ppm upto 120 days of storage. The mean adult emergence in these treatments was 0.80, 0.67 and 1.00 respectively. Diflubenzuron 25 WP 1 ppm and Novaluron 10 EC 1 ppm were least effective in terms of adult emergence.

Key words : *Callosobruchus chinensis, neem oil, azadirachtin, NSKE, adult emergence, Insect growth regulators, chickpea.*

Introduction

India is one of the largest producer and consumer of pulses in the world. One fourth of world's pulse production and largest import of pulses also occurs in India. During the last 15 years India has achieved the remarkable growth in total pulse production with a total production of 25.58 million MT during 2020-21 (1). During the same year chickpea (*Cicer arietnum* L.) had a lion's share of 49.3% in the total pulses production. Chickpea is not only a rich source of protein, carbohydrate and other essential constituents of human diet but also improves soil health by fixing nitrogen in soil through symbiotic nitrogen fixation process and enhance the natural enemies population (2). India contributes 70 per cent of total world Bengal gram production of 116.2 lakh tonnes cultivated under 112 lakh hectares with productivity of 1036 kg/hectare in 2020- 21 (3). According to an estimate, 60 per cent of whole production that produced is destroyed by insect pests in which storage insect-pest play an important role. Among that pulse beetle, *Callosobruchus chinensis* L. (Coleoptera : Bruchidae) is a serious storage pest of different pulse grains in the tropics because of the favourable climatic conditions for their proliferation. This beetle can cause losses upto 30 per cent in a short period of time and can damage 100 per cent of stored seeds causing weight loss upto 60 per cent (4). Stored grain pests are usually controlled by fumigation with ethylene dibromide or aluminium phosphide. Most of synthetic pesticides are persistent in environment; they cause resistance in target pests and destroy non-target organism. Residual toxicity caused by organophosphorus insecticides such as dichlorvos and malathion and synthetic pyrethroids have been reported to cause carcinogenic effects (5). Concern about the impact of pesticides on both health and environment has resulted in the search of alternative control measures having low toxicity to non-target organisms and less persistence (6). In the search of new control tactics, insect growth regulators (IGRs) have been receiving a great interest in the stored product insect control. IGRs posses a novel mode of action, affecting the molting and metamorphosis process in insects. By realizing the importance of these botanicals, it is imperative that there is a need to examine and evaluate some IGRs in stored commodities. It improves the quality and enhance the yield (7). In that direction, the present investigation was carried out to evaluate some IGRs for management of *C. chinensis* in chickpea.

Materials and Methods

The experiment was conducted under laboratory conditions at the Department of Entomology, S.K.N. College of Agriculture, Jobner, Rajasthan during 2020-2021. To maintain the stock culture of *Callosobruchus chinensis* L, the pure culture already maintained in Department of Entomology, S.K.N. College of Agriculture, Jobner was used. The chickpea grains were cleaned, rinsed with water, sun dried and were subjected to sterilisation at 60°C temperature for five hours to eliminate any insect infestation, hidden or otherwise. These grains were conditioned for 48 hours at 29±1.5°C temperature and 70±5.0% relative humidity. For maintaining subsequent insect culture, 20 pairs of newly emerged adults were released for oviposition in the glass jar (size

Received : May-2022; Revised : May-2022; Accepted : May-2022

Table-1 : Insect growth regulators (IGRs) as seed protectant against pulse beetle, *C. chinensis*.

IGR	Dosages			
1. Diflubenzuron 25WP	1 ppm	5 ppm	10 ppm	15 ppm
2. Novaluron 10EC	1 ppm	5 ppm	10 ppm	15 ppm
3. Lufenuron 5.4EC	1 ppm	5 ppm	10 ppm	15 ppm
4. Pyriproxyfen	1 ppm	5 ppm	10 ppm	15 ppm
5. Buprofenzin 25SC	1 ppm	5 ppm	10 ppm	15 ppm
6. Neem oil	0.1%	0.5%	1.0%	-
7. NSKE	1.0%	2.5%	5.0%	-
8. Deltamethrin 2.8EC	2 ppm	-	-	-
9. Azadirachtin	5000 ppm	10000 ppm	15000 ppm	
10. Control (Untreated)	-	-	-	-

Table-2 : Adult emergence (numbers) due to F_1 *Callosobruchus chinensis* (L.) in insect growth regulator treated chickpea seeds after certain period of storage.

S. No.	Treatment	Dose	24 hours	60 DAT	120 DAT	180 DAT	240 DAT	Mean
1.	Diflubenzuron	1 ppm	5.00 (0.77)	10.00 (1.04)	14.00 (1.18)	21.67 (1.36)	36.00 (1.57)	17.33
		5 ppm	2.67 (0.56)	6.67 (0.88)	11.00 (1.08)	16.00 (1.23)	26.67 (1.44)	12.60
		10 ppm	0.00 (0.00)	2.00 (0.46)	5.67 (0.82)	8.00 (0.95)	11.33 (1.09)	5.40
		15 ppm	0.00 (0.00)	0.00 (0.00)	4.00 (0.69)	5.33 (0.80)	8.67 (0.98)	3.60
2.	Novaluron	1 ppm	6.00 (0.85)	11.00 (1.08)	15.33 (1.21)	22.67 (1.37)	38.67 (1.60)	18.73
		5 ppm	2.67 (0.56)	7.00 (0.90)	13.33 (1.16)	18.00 (1.28)	29.00 (1.48)	14.00
		10 ppm	0.67 (0.16)	3.00 (0.59)	7.00 (0.90)	11.00 (1.08)	18.00 (1.28)	7.93
		15 ppm	0.00 (0.00)	0.00 (0.00)	4.67 (0.75)	7.00 (0.90)	11.33 (1.09)	4.60
3.	Lufenuron	1 ppm	2.00 (0.46)	3.33 (0.63)	8.33 (0.97)	11.67 (1.10)	18.67 (1.29)	8.80
		5 ppm	0.67 (0.16)	2.67 (0.56)	7.00 (0.90)	9.33 (1.01)	15.67 (1.22)	7.07
		10 ppm	0.33 (0.10)	1.67 (0.42)	4.00 (0.69)	5.00 (0.77)	8.67 (0.98)	3.93
		15 ppm	0.00 (0.00)	0.00 (0.00)	2.67 (0.56)	4.00 (0.69)	6.67 (0.88)	2.67
4.	Pyriproxyfen	1 ppm	2.33 (0.52)	3.00 (0.60)	7.00 (0.90)	10.00 (1.04)	15.67 (1.22)	7.60
		5 ppm	0.67 (0.16)	2.33 (0.52)	5.33 (0.80)	7.00 (0.90)	11.67 (1.10)	5.40
		10 ppm	0.00 (0.00)	0.67 (0.16)	2.67 (0.56)	4.33 (0.73)	7.00 (0.90)	2.93
		15 ppm	0.00 (0.00)	0.00 (0.00)	2.33 (0.50)	3.00 (0.59)	4.67 (0.75)	2.00
5.	Buprofenzin	1 ppm	3.00 (0.60)	5.00 (0.77)	11.33 (1.09)	16.33 (1.24)	27.00 (1.45)	12.53
		5 ppm	2.00 (0.48)	4.00 (0.69)	9.67 (1.03)	14.67 (1.19)	24.67 (1.41)	11.00
		10 ppm	1.33 (0.32)	3.00 (0.60)	8.00 (0.95)	12.00 (1.11)	19.67 (1.32)	8.80
		15 ppm	0.00 (0.00)	0.00 (0.00)	5.33 (0.80)	6.33 (0.86)	11.00 (1.08)	4.53
6.	Neem oil	0.1%	2.67 (0.56)	4.33 (0.72)	10.33 (1.05)	15.67 (1.22)	24.00 (1.40)	11.40
		0.5%	1.67 (0.42)	2.67 (0.56)	8.33 (0.97)	13.00 (1.15)	22.00 (1.36)	9.53
		1%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.33 (0.10)	3.67 (0.67)	0.80
7.	NSKE	1%	3.00 (0.60)	5.33 (0.80)	11.00 (1.08)	18.33 (1.29)	30.00 (1.49)	13.53
		2.5%	2.00 (0.46)	4.00 (0.69)	9.00 (1.00)	15.67 (1.22)	26.33 (1.44)	11.40
		5.0%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.33 (0.10)	3.00 (0.59)	0.67
8.	Deltamethrin	2 ppm	1.67 (0.42)	2.67 (0.56)	5.33 (0.80)	8.00 (0.95)	12.67 (1.14)	6.07
9.	Azadirachtin	5000 ppm	2.67 (0.56)	4.00 (0.70)	6.33 (0.86)	11.00 (1.08)	18.00 (1.28)	8.40
		10000 ppm	1.67 (0.42)	2.33 (0.52)	3.67 (0.67)	5.67 (0.82)	8.33 (0.97)	4.33
		15000 ppm	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.33 (0.10)	4.67 (0.75)	1.00
10.	Control		40.33 (1.62)	44.00 (1.65)	43.33 (1.65)	45.33 (1.67)	44.00 (1.65)	43.40
	SEm±		0.07	0.05	0.03	0.04	0.02	
	CD (P=0.05)		0.20	0.13	0.09	0.11	0.05	

18×10 cm) containing 200 g chickpea grains. For handling the infested grains and insects, a forcep and a camel hair brush was used. Subsequent experiment was conducted at 29±1.5°C temperature and 70±5.0% relative humidity.

Treatment of grain : Sterilized and conditioned chickpea grain (250 g) was treated with different dosages of insect growth regulators (Table-1). After this, 30 g from treated lot of each growth regulator was taken in glass vials (10×5.0 cm). Two pairs of newly emerged adults (0 to 24 hours old and equal sex) were released in each glass vial. Three replications of each treatment were maintained and an untreated check was maintained for comparison.

Method of recording observations : The adult emergence caused by one generation was recorded by visual count at three days interval up to one generation and will be discarded. The experiment was repeated after

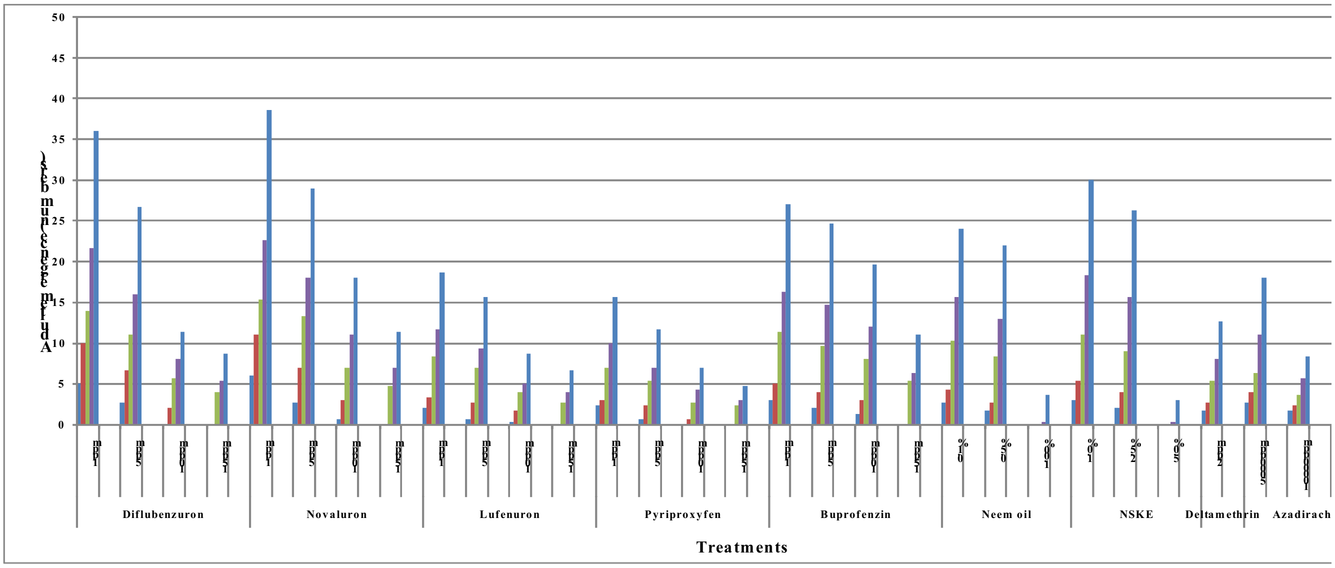

Figure-1 : Adult emergence (numbers) due to F_1 of pulse beetle, *Callosobruchus chinensis* (L.) in insect growth regulator (IGR) treated chickpea seeds after specified period of storage.

24 hours, 60, 120, 180 and 240 days after treatment and the observations on adult emergence and weight loss were recorded.

Statistical analysis : Number of adults emerged were transformed into log X+1 values for analysis of variance.

Results and Discussion

Adult emergence : In order to record the adult emergence of *Callosobruchus chinensis* (L.), the samples were drawn from the treated grain lot to record F_1 progeny adult emergence from the insects released after 24 hours of grain treatment, 60 days, 120 days, 180 days and 240 days of treatment, and adults were released. Thus the F_1 adult emergence was recorded to evaluate the efficacy of IGRs after different intervals of grain treatment.

After 24 hours, no F_1 progeny adult emergence was recorded in diflubenzuron 10 and 15 ppm, novaluron 15 ppm, lufenuron 15 ppm, pyriproxyfen 10 and ppm, buprofenzin 15 ppm azadirachtin 15000 ppm, neem oil 1% and NSKE 5.0%. Lower adult emergence (0.67 adults each) was recorded in treatments such as novaluron 10 ppm and pyriproxyfen 5 ppm, Treatments such as diflubenzuron 1 ppm, novaluron 1 ppm, buprofenzin 1 ppm and NSKE 1.0% exhibited higher adult emergence (3.00- 6.00 adults each). All other treatments were ranked in the middle order. The adult emergence in all treatments was significantly lower when compared to that of control (40.33 adults).

After 60 days of treatment, no adult emergence was recorded in treatments such as diflubenzuron 15 ppm, novaluron 15 ppm, lufenuron 15 ppm, pyriproxyfen 15 ppm, buprofenzin 15 ppm, neem oil 1.0%, NSKE 5.0% and Azadirachtin 15000 ppm. Higher efficiency was recorded by treatments such as diflubenzuron 10 ppm, novaluron 10 ppm, lufenuron 5, 10 and 15 ppm, pyriproxyfen 1, 5 and 10 ppm, buprofenzin 10 ppm, neem oil 0.5%, deltamethrin 2 ppm and azadirachtin 15000 ppm (0.67- 3.00 adults). Higher adult emergence was recorded in treatments such as diflubenzuron 1 and 5 ppm, novaluron 1 and 5 ppm which differed significantly with that of control (44.00 adults). All other treatments can be ranked in the middle order.

After 120 days of treatment, lower adult emergence (2.00- 4.00 adults) was recorded in treatments such as diflubenzuron 15 ppm, lufenuron 10 ppm, pyriproxyfen 10 and 15 ppm and azadirachtin 10000 ppm. The treatments in which adults failed to emerge were neem oil 1%, NSKE 5.0% and azadirachtin 15000 ppm. Lower efficiency (9.00- 15.33 adults) was recorded in treatments such as diflubenzuron 1 and 5 ppm, novaluron 1 and 5 ppm, buprofenzin 1 and 5 ppm, neem oil 0.1%, NSKE 1 and 2.5% which differed significantly with that of control (43.33 adults). All other treatments can be ranked in the middle order.

After 180 days of treatment the most effective treatments in which very less adult emergence (0.33) were recorded includes neem oil 1.0%, NSKE 5.0% and azadirachtin 15000 ppm. It was followed by treatments such as diflubenzuron 15 ppm, lufenuron 10 and 15 ppm, pyriproxyfen 10 and 15 ppm and azadirachtin 10000 ppm which exhibited higher efficiency as 4.00- 5.67 adults emerged. The treatments which exhibited lower efficiency in which 10 or more adults emerged includes diflubenzuron 1 and 5 ppm, novaluron 1, 5 and 10 ppm, lufenuron 1 ppm, buprofenzin 1, 5 and 10 ppm, neem oil

0.1 and 0.5%, NSKE 1 and 2.5% and azadirachtin 5000 ppm.

After 240 days of treatment the adult emergence ranged from 3.00-38.67 among various treatments used. The most and least effective treatments were NSKE 5.0% and novaluron 1 ppm respectively. The treatments in which less than 5 adults emerged includes pyriproxyfen 15 ppm, neem oil 1.0%, NSKE 5.0% and azadirachtin 15000 ppm. Higher adult emergence (15.67- 38.67) was recorded in treatments such as diflubenzuron 1 and 5 ppm, novaluron 1, 5 and 10 ppm, lufenuron 1 and 5 ppm, pyriproxyfen 1 ppm, buprofenzin 1, 5 and 10 ppm, neem oil 0.1 and 0.5%, NSKE 1 and 2.5% and azadirachtin 5000 ppm. All treatments used differed significantly with that of control (44.00 adults). The ascending pattern of adult emergence observed was NSKE, neem oil, azadirachtin, pyriproxyfen, lufenuron, diflubenzuron, buprofenzin, novaluron and deltamethrin (Table-1, Fig.-1).

The pesticidal activity of neem oil and cannabidiol (extracted from *Cannabis sativa* L.) was studied by (8). Mortality of 4th instar larvae of *Tribolium confusum*, *Oryzaephilus surinamensis* and *Plodia interpunctella* was observed in relation to dosage, time exposure intervals and product types. This was in accordance with our result that no adult emergence was observed upto 180 days of seed treatment with neem oil. (9) found that percentage egg hatching in *Trogoderma granarium* was reduced; this may be due to entry of oil into the micropyle that leads to the death of fetus. Mung bean seeds when treated with 0.03% azadirachtin, mean egg laying by pulse beetle was reduced to a great extend when compared to other treatments (10). This was in conformity with the present results. More than 50% adult mortality in khapra beetle was observed in groundnut seeds treated with neem seed kernel extract at 500 mg/ml. There was a negative correlation between dosage and adult emergence, seed damage and weight loss (11). The present findings were in agreement with this study that increase in neem kernel extract dosage decreased the adult emergence. The results showed that pulse beetle adult emergence in seeds treated with pyriproxyfen 15 ppm were nil upto 60 days after treatment. Similar findings occurred in *O. surinamensis, T. castaneum* and *T. granarium* when grains of wheat, maize, rice, and oats were exposed to pyriproxyfen with residual efficacy for 16 weeks at 4 mg kg^{-1} (12). (5) found that pulse beetle showed lowest susceptibility to buprofezin and lufenuron among five biorational molecules used in a bioassay. This finding comes in the support of our results that these two insect growth regulators are less effective than neem based products such as neem oil, NSKE and azadirachtin.

Acknowledgements

We are very grateful to Department of Entomology, S.K.N College of Agriculture for assisting with laminar air flow chamber for UV radiation treatment and other facilities required for completing the research work. We are also grateful to Professor K.C. Kumawat for his correction and editorial work on the manuscript.

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