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TOXICITY OF SOME INSECT GROWTH REGULATORS (IGRS) AGAINST DIFFERENT LIFE STAGES OF DUSKY COTTON BUGS *OXYCARENUS HYALINIPENNIS* COSTA (HEMIPTERA: LYGAEIDAE: OXYCARENINAE)

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Abstract

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Different concentrations of five Insect Growth Regulators (IGRs) including Runner® 240SC (Methoxyfenozide), Silent® 5EC (Lufenuron), Capture® 20SC (Triflumuron), Priority® 10.8EC (Pyriproxyfen) and Match® 50EC (Lufenuron) were tested against dusky cotton bug, *Oxycarenus hyalinipennis*. The experiment was conducted under laboratory conditions with three replications of each concentration. Pre-determined numbers of *O. hyalinipennis* were released on filter papers treated with nine different concentrations of each IGR to determine their LC_{50} values. The results revealed that Silent® for the 1st, 2nd, 4th, 5th instars and for male insects after 72 hours, and Match® for the 3rd and 5th instars after 24 and 72 hours, respectively caused severe mortality at their lowest LC_{50} values. On the basis of these findings, it is concluded that Silent® and Match® are highly toxic and effective against various life stages of *O. hyalinipennis* and hence can be recommended for the control of *O. hyalinipennis* in integrated pest management (IPM) program. However, all the tested chemicals need to reestablish their respective field recommended doses, in case any of them can constitute an essential part in the pest management program of the cotton pest complex.

Key words: Dusky cotton bug, Insect growth regulators, integrated pest management, mortality, toxicity

Introduction

Dusky cotton bug, *O. hyalinipennis* Costa belongs to family Lygaeidae and now classified under the family Oxycarenidae and superfamily Lygaeoidea (Henry, 1997). It becomes major pest of cotton due to qualitative and quantitative losses to cotton crop in many countries. Henry (1983) reported the losses caused by dusky cotton bug include decrease in germination, loss in cottonseed weight and reduction in oil quality of the seed. Moreover, dusky cotton bug crushed during ginning process and stained the lint of cotton to pinkish color (Henry, 1983).

Mostly, dusky cotton bug hides into the cotton bolls and their damage comes insight at the time of boll opening. So, no insecticides dosage recommendations are made for this pest. However, the insecticide application for bollworms during mid to late seasons minimizes the population of these bugs successfully (Vennila et al., 2007). It is, therefore necessary to screen out highly effective, toxic and/or deterrent insecticides that can be recommended against dusky cotton bug to minimize the chances of its settling down in cotton field as well as in ginneries to cause damage and staining of cotton fiber.

IGRs are belonging to different groups of insecticides, affecting the insect specific phenomena with disruption of growth and development of the pest species. They mostly influence the development of immature stages, and disturb their metamorphosis and reproduction (Retnakaran et al., 1985; Graf, 1993).

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They are becoming an important part in the management strategies of insect pests (Grenier and Grenier, 1993). There is a need to utilize these growth regulators to control dusky cotton bug due to their efficiency against number of insect pests. The objective of present research was to assess the toxicity and dose rates of some insect growth regulators (IGRs) against target pest.

Materials and Methods

The experiment was conducted at the Integrated Pest Management (IPM) laboratory in Department of Entomology, University of Agriculture Faisalabad, Pakistan, during 2011–2012.

Collection of the Dusky cotton bug

Mixed population of dusky cotton bug, *O. hyalinipennis* was collected from cotton field in large plastic jars by shaking the infested plants parts inside the jars. The collected population was brought in the IPM laboratory, separated into adult and immature (nymphs) populations and placed them into separate rearing cages with the food.

Preparation of pesticide dilutions

The Petri dishes used in the trial were cleaned thoroughly with a detergent, rinsed with distilled water and then air dried. A stock solution (D-1) for each chemical was prepared and the serial of required dilutions were made by using half of the stock solution in other containers. The under study concentrations are given in Table 1.

Toxicological studies

The prepared nine dilutions of each insecticide were applied onto separate filter paper and seed cotton. The filter paper was dipped in respective dilutions for 10 minutes, whereas; seed cottons were sprayed with different concentrations through atomizer. Both the treated filter paper and seed cotton were air-dried for 20 minutes before the release of dusky cotton bug. After air-drying, filter paper was pasted on the bottom of Petri dish, and the treated seed cotton were placed on the pasted filter paper. Three replications were made for each concentration/dilution. A counted number of each life stages of dusky cotton bug were released in separate Petri dishes through a small hole made in the center of the lid of each Petri dish. After release, the hole was closed with firm meshed cloth for ventilation. The Petri dishes will be placed inside incubator maintained at 30±1°C and 65±5% Relative Humidity. This experiment was repeated twice (in two years) for each insecticide. A parallel control was also set for each treatment. The mortality data was collected at 12, 24, 48 and 72 hours post treatment intervals.

Data analysis

The collected data was subjected to Probit analysis after converting the data into percent corrected mortality as described by Henderson and Tilton (1995) to determine LC_{50}, LC_{75}, LC_{90} and LC_{100}. Henderson and Tilton (1995) formula is given below:

$$\text{Corrected \% Mortality} = \left(1 - \frac{n \text{ in } C_o \text{ before treatment} \times n \text{ in } T \text{ after treatment}}{n \text{ in } C_o \text{ after treatment} \times \text{n in T before treatment}}\right) \times 100,$$

where n = Insect population, T = treated, C_o = control

Results

The laboratory experiment using different concentrations revealed that Silent® had the lowest LC_{50} values i.e., 10.0, 5.8, 3.2 and 1.1 ml/L; 15.0, 7.3, 3.3 and 1.8 ml/L; 14.4, 7.9, 3.6 and 1.4 ml/L; and 10.8, 6.4, 3.1 and 1.6 at 12, 24, 48 and 72 hours, respectively, for the 1st, 2nd, 4th and 5th instars of dusky cotton bug (Tables 2 and 3). Among all treatments, Silent® had the lowest LC_{50} values i.e., 11.7, 2.5 and

Table 1

IGRs and their concentrations used against different life stages of dusky cotton bug, Oxycarenus hyalinipennis under laboratory conditions

Insecticide Name	Active ingredient	Recommended dose ml / L	Concentrations
Runner® 240SC	Methoxyfenozide	2 ml / L	0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32 ml/L
Silent® 5EC	Lufenuron	2 ml / L	0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32 ml/L
Capture® 20SC	Triflumuron	2 ml / L	0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32 ml/L
Priority® 10.8EC	Pyriproxyfen	2 ml / L	0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32 ml/L
Match® 50EC	Lufenuron	2 ml / L	0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32 ml/L

Table 2

LC50 values of different concentrations of some insect growth regulators (IGRs) for 1st, 2nd, 3rd and 4th instars of dusky cotton bug, Oxycarenus hyalinipennis Costa at C.I. 95 % after 12, 24, 48 and 72 hours

IGRs	Time (Hrs.)	1st Instar			2nd Instar			3rd Instar			4th Instar		
		LC50 (95% FL)	Slope ± SE	χ2	LC50 (95% FL)	Slope ± SE	χ2	LC50 (95% FL)	Slope ± SE	χ2	LC50 (95% FL)	Slope ± SE	χ2
Runner®	12 h	23.9 (1.79-3.42)	0.57±0.05	8,2	46.0 (2.90-8.82)	0.45±0.04	12,1	70.7 (3.67-19.5)	0.34±0.04	7,4	59.6 (3.64-12.2)	0.49±0.05	7,2
	24 h	18.2 (1.32-2.72)	0.44±0.04	5,1	36.7 (2.36-6.77)	0.42±0.04	11,5	50.0 (2.68-13.1)	0.30±0.04	3,9	44.9 (2.74-9.10)	0.41±0.04	2,9
	48 h	12.4 (0.92-1.76)	0.42±0.03	1,6	25.1 (1.76-3.97)	0.46±0.04	1,9	16.8 (1.13-2.81)	0.34±0.03	3,8	23.0 (1.62-3.63)	0.44±0.04	10,8
	72 h	5.7 (0.44-0.74)	0.43±0.03	4,7	6.9 (0.52-0.93)	0.39±0.03	7,5	10.4 (0.75-1.51)	0.37±0.03	5,2	9.9 (0.75-1.37)	0.42±0.03	2,5
Silent®	12 h	10.0 (0.78-1.29)	0.50±0.03	6,01	15.0 (1.07-2.28)	0.39±0.03	1,8	11.7 (0.84-1.76)	0.36±0.03	2,4	14.4 (1.06-2.11)	0.42±0.03	1,9
	24 h	5.8 (0.46-0.75)	0.44±0.03	4,6	7.3 (0.50-1.11)	0.29±0.03	3,4	6.0 (0.43-0.86)	0.32±0.03	0,4	7.9 (0.59-1.08)	0.39±0.03	2,2
	48 h	3.2 (0.25-0.40)	0.44±0.03	7,2	3.3 (0.24-0.44)	0.34±0.03	1,2	2.5 (0.17-0.36)	0.27±0.02	30,9	3.6 (0.27-0.47)	0.37±0.03	1,4
	72 h	1.1 (0.08-0.14)	0.42±0.02	3,06	1.8 (0.13-0.24)	0.35±0.02	1,1	2.5 (0.19-0.32)	0.41±0.03	2,7	1.4 (0.11-0.19)	0.37±0.02	2,08
Capture®	12 h	64.4 (3.98-15.90)	0.44±0.05	10,2	26.3 (1.85-4.14)	0.47±0.04	9,1	31.5 (2.12-5.36)	0.45±0.04	9,9	39.8 (2.63-6.99)	0.48±0.05	12,4
	24 h	32.1 (2.02-6.12)	0.37±0.04	6,2	14.6 (1.07-2.13)	0.42±0.03	4,2	20.9 (1.45-3.34)	0.40±0.04	7,6	28.4 (1.87-5.03)	0.40±0.04	2,1
	48 h	14.8 (1.05-2.27)	0.38±0.03	4,3	8.6 (0.65-1.16)	0.42±0.03	6,8	17.2 (1.19-2.76)	0.37±0.03	2,05	16.6 (1.17-2.58)	0.39±0.03	4,1
	72 h	9.7 (0.76-1.25)	0.50±0.03	9,9	6.2 (0.49-0.79)	0.47±0.03	10,04	9.4 (0.69-1.33)	0.38±0.03	3,7	8.7 (0.64-1.22)	0.38±0.03	3,8
Priority®	12 h	77.7 (4.48-17.77)	0.50±0.06	5,1	43.1 (2.81-7.81)	0.48±0.05	12,6	96.0 (5.18-25.0)	0.47±0.06	13	47.9 (3.03-9.13)	0.47±0.05	12,4
	24 h	40.9 (2.72-7.17)	0.51±0.05	6,6	40.2 (2.52-7.76)	0.40±0.04	14,1	57.2 (3.43-12.0)	0.44±0.05	13,3	43.2 (2.62-8.85)	0.38±0.04	8,1
	48 h	35.8 (2.27-6.75)	0.40±0.04	9,2	16.4 (1.17-2.49)	0.40±0.03	17,3	15.9 (1.21-2.20)	0.50±0.04	24,43	13.3 (0.96-1.98)	0.39±0.03	6,6
	72 h	8.4 (0.68-1.04)	0.57±0.04	26,01	7.1 (0.56-0.91)	0.46±0.03	25,1	7.2 (0.59-0.89)	0.57±0.03	24,4	3.0 (0.24-0.36)	0.56±0.03	24,3
Match®	12 h	38.9 (2.44-7.48)	0.40±0.04	5,7	38.7 (2.59-6.70)	0.49±0.05	14,2	49.1 (2.87-10.7)	0.38±0.04	5,2	40.5 (2.55-7.77)	0.41±0.04	12,3
	24 h	29.9 (1.85-5.87)	0.34±0.03	2,9	39.4 (2.46-7.67)	0.40±0.04	10,3	0.1 (0.005-0.023)	0.43±0.04	8,4	30.4 (1.95-5.59)	0.38±0.04	9,5
	48 h	24.0 (1.44-5.01)	0.29±0.03	3,7	29.8 (1.89-5.59)	0.36±0.04	5,6	4.0 (0.32-0.50)	0.45±0.03	28,6	7.5 (0.56-1.03)	0.37±0.03	16,8
	72 h	4.9 (0.35-0.69)	0.31±0.03	6,5	4.9 (0.40-0.58)	0.59±0.03	17,7	3.0 (0.23-0.38)	0.39±0.03	18,6	2.7 (0.21-0.34)	0.45±0.03	32,6

FL - Fiducial limits

2.5 at 12, 48 and 72 hours, respectively, while Match® had the lowest LC_{50} value i.e., 0.1 ml/L at 24 hours for the 3rd instars of dusky cotton bug (Table 2). For male dusky cotton bug, Match® had the lowest LC_{50} value i.e., 42.0 ml/L at 12 hours; Priority® had 18.3 and 8.1 ml/L at 24 and 48 hours, respectively, while Silent® had 2.0 ml/L at 72 hours (Table 3). However for female dusky cotton bugs, Match® had LC_{50} value i.e., 36.6 ml/L at 12 hours; Priority® had 25.1 ml/L at 24 hours; Capture® had 8.3 ml/L at 48 hours: while Runner® had 2.4 ml/L at 72 hours (Table 3).

Table 3

LC50 values of different concentrations of some insect growth regulators (IGRs) for 5th instar and male and female of dusky cotton bug, Oxycarenus hyalinipennis Costa at C.I. 95 % after 12, 24, 48 and 72 hours

IGRs	Time (Hrs.)	5th Instar			Male			Female		
		LC50 (95% FL)	Slope ± SE	χ2	LC50 (95% FL)	Slope ± SE	χ2	LC50 (95% FL)	Slope ± SE	χ2
Runner®	12 h	43.2 (2.55-9.34)	0.36±0.04	5,6	52.1 (3.15-10.7)	0.43±0.04	14,08	77.2 (4.46-17.5)	0.50±0.06	9,8
	24 h	25.3 (1.60-4.75)	0.34±0.03	2,9	52.8 (2.98-12.3)	0.36±0.04	4,5	64.4 (3.44-16.9)	0.35±0.04	7,07
	48 h	15.5 (1.03-2.65)	0.32±0.03	1,8	16.7 (1.16-2.67)	0.37±0.03	7,3	19.6 (1.19-3.96)	0.27±0.03	12,6
	72 h	8.9 (0.68-1.20)	0.43±0.03	3,3	2.6 (0.19-0.33)	0.36±0.02	16,1	2.4 (0.19-0.30)	0.47±0.03	11,7
Silent®	12 h	10.8 (0.82-1.48)	0.43±0.03	2,6	117.0 (5.19-46.2)	0.31±0.04	11,05	83.2 (4.56-20.8)	0.44±0.05	11,3
	24 h	6.4 (0.50-0.84)	0.43±0.03	4,1	62.3 (3.12-18.6)	0.29±0.04	8,4	62.9 (3.59-14.4)	0.41±0.04	3,1
	48 h	3.1 (0.24-0.40)	0.41±0.03	1,7	8.8 (0.66-1.22)	0.39±0.03	8,5	51.2 (2.68-14.0)	0.30±0.04	1,03
	72 h	1.6 (0.12-0.21)	0.41±0.02	0,5	2.0 (0.15-0.26)	0.37±0.02	9,8	4.6 (0.30-0.75)	0.23±0.02	2,6
Capture®	12 h	17.3 (1.35-2.32)	0.57±0.04	9,9	57.8 (3.31-13.2)	0.39±0.04	12,1	42.0 (2.54-8.60)	0.38±0.04	11,04
	24 h	12.2 (0.96-1.62)	0.52±0.04	4,1	57.8 (3.10-14.9)	0.33±0.04	10,06	29.1 (1.87-5.34)	0.37±0.04	9,2
	48 h	8.2 (0.65-1.05)	0.49±0.03	6,9	12.4 (0.94-1.70)	0.46±0.03	13,3	8.3 (0.65-1.09)	0.45±0.03	13,3
	72 h	5.2 (0.41-0.66)	0.47±0.03	4,2	2.6 (0.21-0.31)	0.55±0.03	9,8	6.4 (0.48-0.88)	0.37±0.03	5,8
Priority®	12 h	46.6 (3.02-8.54)	0.49±0.05	10,1	61.5 (3.64-13.2)	0.45±0.05	12,8	55.8 (3.57-10.5)	0.54±0.05	9,9
	24 h	44.1 (2.70-8.90)	0.40±0.04	12,5	18.3 (1.35-2.66)	0.47±0.04	17,3	25.1 (1.87-3.63)	0.56±0.05	15,4
	48 h	18.1 (1.32-2.68)	0.44±0.04	28,8	8.1 (0.64-1.04)	0.49±0.03	29,09	19.3 (1.30-3.22)	0.36±0.03	12,09
	72 h	6.2 (0.50-0.78)	0.50±0.03	40,2	3.3 (0.26-0.40)	0.50±0.03	38,9	2.8 (0.22-0.35)	0.48±0.03	34,06
Match®	12 h	31.3 (2.03-5.66)	0.40±0.04	7,6	42.0 (2.59-8.36)	0.40±0.04	12,2	36.6 (2.46-6.27)	0.48±0.04	5,8
	24 h	31.5 (1.85-6.80)	0.31±0.03	2,2	36.8 (2.22-7.56)	0.35±0.04	10,3	39.4 (2.40-7.95)	0.37±0.04	7,8
	48 h	7.9 (0.59-1.11)	0.37±0.03	16,3	25.8 (1.61-4.99)	0.32±0.03	17,2	9.8 (0.75-1.35)	0.42±0.03	8,2
	72 h	2.0 (0.15-0.26)	0.38±0.02	25,1	5.6 (0.43-0.75)	0.38±0.03	35,5	2.7 (0.22-0.34)	0.46±0.03	20,6

FL - Fiducial limits

LC_{50} values for Silent® were 1.1, 1.8, 1.4, 1.6 and 2.0 ml/L which were 1.9, 1.1, 1.5, 1.6 and 2.0 time less than their respective field recommended doses, for 1st, 2nd, 4th, 5th instars and male of dusky cotton bug, respectively, after 72 hours. While LC_{50} values for Match® were 0.1 and 2.0 ml/L which were 20 and 1 time less than their respective field recommended doses, for 3rd and 5th instars of dusky cotton bug, respectively, after 24 and 72 hours, respectively. These results indicated that after 72 hours, Silent® was more toxic against 1st, 2nd, 4th, 5th instars and male of dusky cotton bug, while after 24 and 72 hours, Match® was found to be more toxic against 3rd and 5th instars of dusky cotton bug. The low-

Table 4

Means of the percentage mortality of all life stages of dusky cotton bug, Oxycarenus hyalinipennis Costa at various interactions between concentrations and exposure intervals of Silent® and Match®

Concentrations	Silent®					Match®	
	72 Hours					24 Hours	72 Hours
	1st instar	2nd instar	4th instar	5th instar	Male	3rd instar	5th instar
0.125 ml/L	20.3 klmnop	24.0 jklmnop	20.8 jklm	20.0 klmn	15.0 defg	3.3 d	11.7 efgh
0.25 ml/L	27.0 jklmnop	30.8 hijklmno	27.8 ijkl	27.0 ijklm	26.7 bcdefg	6.7 d	15.0 efgh
0.5 ml/L	41.1 fghijklm	34.5 hijklmn	41.5 fghijk	34.5 ghijkl	35.0 abcdefg	18.3 bcd	40.0 abcdefgh
1 ml/L	51.1 cdefghij	41.1 fghijklm	44.8 efghij	44.9 efghij	38.0 abcdefg	21.7 bcd	51.7 abcdef
2 ml/L	61.9 bcdefgh	48.1 defghij	54.8 cdefgh	54.9 cdefg	55.0 abcd	28.3 abcd	55.0 abcde
4 ml/L	69.2 abcdef	62.2 abcdef	65.1 abcdef	62.2 bcdef	66.7 ab	33.3 abcd	68.3 abc
8 ml/L	79.7 abc	68.6 abcd	72.6 abcd	72.6 abcd	66.7 ab	43.3 abcd	66.7 abcd
16 ml/L	85.9 ab	75.6 abc	79.2 abc	82.6 ab	80.0 a	48.3 abcd	75.0 ab
32 ml/L	92.9 a	86.2 a	89.7 a	89.7 a	80.0 a	58.3 abc	83.3 a
0	0.0 p	0.0 p	0.0 m	0.0 n	0.0 g	0.0 d	0.0 h

est LC_{50} values of above mentioned IGRs showed their high effectiveness against different life stages of dusky cotton bug over field recommended doses.

The ANOVA showed that under laboratory conditions, various concentrations of different IGRs and exposure intervals factors were highly significant ($p < 0.01$) but their interaction had nonsignificant ($p > 0.05$) impact on the mortality of different life stages of dusky cotton bug except Match®, Capture® and Runner® whose interaction with exposure intervals had significant ($p < 0.05$) impact on the mortality of 2nd instars, male and female dusky cotton bug, respectively.

Discussion

As the results showed, Silent® caused more than 50% mortality in 1st, 2nd, 4th, 5th instars and for male of dusky cotton bug after 72 hours. In these cases, maximum mean mortalities were 92.9, 86.2, 89.7, 89.7 and 80.0% for 1st, 2nd, 4th, 5th instars and for male dusky cotton bug respectively at 32 ml/L. While Match® was also responsible to cause 58.3% and 83.3% mortality in the 3rd and 5th instars dusky cotton bug after 24 and 72 hours, respectively at 32 ml/L (Table 4).

The Probit analysis indicated that LC_{50}> Field Recommended Dose (2.0 ml/L) for Runner®, Capture® and Priority® to be less toxic to all different instars including male and female dusky cotton bug at exposure intervals of 12, 24, 48 and 72 hours. However, previously reported studies by Kim et al. (2006) for Runner® had shown that there had no sub lethal effects on adults of plant bug, *Deraeocoris brevis* at the full field rate. Studies by Chernaki-Leffer et al. (2011) for Capture® had shown that its application did not minimize insecticide resistance problems in lesser mealworm, *Alphitobius diaperinus*. Studies by Horowitz et al. (2002) for Priority® had shown that its one application per season in ten years was less toxic against whitefly, *Bemisia tabaci* in cotton fields.

The Probit analysis also indicated that LC_{50}< Field Recommended Dose (2.0 ml/L) for Silent® to be toxic to 1st, 2nd, 4th, 5th instars and male of dusky cotton bug at exposure interval of 72 hours, while LC_{50}< Field Recommended Dose (2.0 ml/L) for Match® to be toxic to 3rd and 5th instars of dusky cotton bug at exposure interval of 24 and 72 hours, respectively. However, previously reported studies by Dharmadasa et al. (2008) for Silent® had shown that it was effective to manage the cardamom thrips, *Sciothrips cardamomi* in plantations of cardamom. Studies by Gogi et al. (2006) for Match® had shown that the populations of whitefly, *Bemisia tabaci* considerably reduced by its application.

Conclusions

On the basis of these findings, it is concluded that Silent® and Match® are highly toxic and effective against various life stages of dusky cotton bug and hence can be recommended for the control of dusky cotton bug in integrated pest management (IPM) program.

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